LNG ship to ship bunkering procedure

Swedish Marine Technology Forum | Linde Cryo AB | FKAB Marine Design
Det Norske Veritas AS | LNG GOT | White Smoke AB

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Publisher Swedish Marine Technology Forum
Museigatan 2, 3rd floor. SE-451 50 UDDEVALLA
Phone: + 46 522-199 32 | Email: info@smtf.se | Web: www.smtf.se

Print No LNG02

Swedish Marine Technology Forum funding through member companies and

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TILLVÄXTVERKET
SWEDISH AGENCY FOR ECONOMIC AND REGIONAL GROWTH

Sparbanksstiftelsen Väst

EUROPEAN UNION
European Regional
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VÄSTRA GÖTALANDSREGIONEN

Summary

This document is a procedural description of how LNG (liquid natural gas) bunkering between two ships should be done.

The document is the result of the joint venture project “LNG bunkering Ship to Ship”, a technology development project carried out by Swedish Marine Technology Forum, FKAB Marine Design, Linde Cryo AB, Det Norske Veritas AS (DNV), LNG GOT and White Smoke AB.

LNG bunkering ship to ship in port with demands for short operation time have not been performed before and this procedure has been worked out to handle the specific details of this operation in a safe way.

The procedure is made for ship to ship bunkering of LNG in a port environment, with a dedicated bunker ship rapidly delivering the fuel to client ships while cargo and passenger handling is still in progress.

The project has developed a LNG bunkering concept that encompasses both the operational bunkering process and technical solutions needed for ship to ship bunkering of LNG.

The conclusion of this study is that LNG bunkering ship to ship is indeed a suitable solution to provide environmentally friendly bunker fuel to larger ships.

The concept is accepted and approved in principle by DNV.

Table of content

Summary 5
Project Members 12
The Working group 12
The Reference group 13
Background 14
Project objectives 16
Approval in principle by DNV 17
Project Method 18
Rules and Guidelines 18
The Results 19
Preface – LNG bunkering ship to ship procedure 21
Bunkering Timeline 22
Glossary 23
1 GENERAL PRINCIPLES 24
1.1 Scope 24
1.2 Control of operations 24
1.3 Responsibility 24
2 CONDITIONS AND REQUIREMENTS 25
2.1 Approval 25
2.2 Ship Compatibility 25
2.3 Transfer Area 25
2.4 Weather Conditions 25
2.5 Light Conditions 25
3 SAFETY 26
3.1 General 26
3.2 EX-Zone 26
3.3 ESD-System 26
3.4 Check-Lists 26
3.5 Instructions (Routines) 26
3.6 Warning signs 26
3.7 Safety during Bunker 27
3.7.1 Smoking and Naked Light 27
3.7.2 Earth on switchboard 27
3.7.3 Electrical Currents 27
3.7.4 Radio and Communication Equipment 27

3.7.5 Radar 28
3.7.6 Electrical storms 28
3.7.7 Fire-Fighting Equipment 28
3.7.8 Accommodation Openings 28
3.7.9 Safety Zone 28
3.7.10 Gas Accumulation 28
3.8 Maintenance 28
3.9 Redundancy 28
3.10 Personnel education and training 29
3.11 Personal protection equipment 29
3.12 Sharp edges 29
4 COMMUNICATIONS 30
4.1 Language 30
4.2 Communication between Ships 30
4.3 Procedure for Communication Failure 30
5 OPERATIONS BEFORE BUNKERING 31
5.1 Preparations 31
5.1.1 LNG Tank System Check 31
5.1.2 Mooring Equipment Check 31
5.1.3 Bunker Hose Check 31
5.1.4 Oil Bunkering 31
5.2 Check-List Before Bunker 31
5.3 Call 32
5.3.1 Safe Communication 32
5.3.2 Mooring Plan 32
5.4 Manoeuvring 32
5.5 Mooring 32
5.5.1 Fender Positioning 32
5.5.2 Fender Type and Size 32
5.5.3 Mooring Operation 32
5.5.4 Mooring Lines Supervision 33
5.6 Connection Communication Link (Option) 33
5.7 Connection of Hoses 33
5.8 Bunker Hoses 34
5.8.1 LNG Bunker Hose and Vapour Return Hose 34
5.8.2 Oil Bunker Hose 34
5.9 Pre-Transfer Bunker Check List 34

6 OPERATIONS DURING BUNKERING 35
6.1 Return of Documents 35
6.1.1 Signed Check-List 35
6.1.2 Signed document with Agreed Amount and Transfer Rate 35
6.2 Open Manual Bunker Valves 35
6.3 Ready Signal Both Ships 35
6.4 Pump Start Sequence 35
6.5 Bunkering 36
6.6 Pump Stop Sequence 36
7 OPERATIONS AFTER BUNKERING 37
7.1 Purging of Bunker Hoses 37
7.2 Close Manual and Remote controlled valves 37
7.3 Disconnection of Hoses 37
7.4 Disconnection Communication Link (Option) 38
7.5 Delivery Bunker Document 38
7.6 Unmooring 38
7.7 Manoeuvring 38
7.8 Inerting of Bunker Lines 38
7.9 Check-list After Bunker 38
8 EQUIPMEN 39
8.1 Bunker Hoses 39
8.1.1 Hose Standards 39
8.1.2 Hose Size and Length 39
8.1.3 Hose Handling 39
8.1.4 Hose Connection 39
8.1.5 Hose Inspection and Testing 39
8.1.6 Marking 39
8.1.7 Differential Pressure Measuring 39
8.2 Bunker Station (Receiving ship) 40
8.3 Break-away Coupling 41
8.4 Mooring Equipment 41
8.5 Personnel Transfers 41
8.6 Lighting 41
8.7 Trays below manifolds 41
8.8 Gas Detectors 41
8.9 Fuel Quality Measuring (Option) 41

9 LNG CARGO SYSTEM DESCRIPTION 42
9.1 General 42
9.2 Equipment 42
9.2.1 General data 42
9.2.2 Tanks 42
9.2.3 Pumps 43
9.2.4 Bunker Stations (System) 43
9.2.5 Piping System 43
9.2.6 Vacuum Insulated Pipes 44
9.2.7 Double Trunk Pipes 44
9.2.8 Safety Valves 44
9.2.9 Vent Mast 44
9.2.10 ESD System 44
9.3 Process 45
10 ESD PHILOSOPHY 46
10.1 Reference 46
10.2 ESD Analysis 46
10.3 The Receiving ship 46
10.4 The Bunker ship 46
10.5 Transfer Interface when Bunkering 47
10.6 ESD Philosophy 48
11 EMERGENCY OPERATIONS 49
11.1 Emergency Signal 49
11.2 State of Readiness for an Emergency 49
11.3 Contingency Planning 49
11.4 Emergency Situations 50
11.5 Safety Drills 50
11.6 Advice on some Emergencies 50
11.6.1 Emergencies during Manoeuvring 50
11.6.2 Procedures for Communication Failure 50
11.6.3 Activation of Emergency Shut-Down Systems (ESD) 50
11.6.4 Procedures for Leakage / Gas Accumulation 51
11.6.5 Accidental LNG Bunker Fuel Release 51
11.6.6 Accidental Oil Bunker Fuel Release and Oil Pollution Control 51

12 GAS HANDLING 52
12.1 General 52
12.2 Safety Information 52
12.2.1 Cryogenic Liquids 52
12.2.2 Risks when inhaling Methane (CH4) Natural Gas 52
12.2.3 Risks when inhaling Nitrogen (N2) Gas 52
12.2.4 Fire 53
12.2.5 Risks when in contact with Cold items and Gas 53
12.2.6 Personal Protection 53
12.2.7 Vapour Fog, Mist 53
12.2.8 Trapped Liquid 53
12.2.9 Training 54

References 55
Appendix A CHECK-LIST BEFORE BUNKERING 56
Appendix B CHECK-LIST PRE-TRANSFER 57
Appendix C CHECK-LIST AFTER BUNKERING 59
Appendix D – Flow Diagram LNG Ship to Ship bunkering 60
Appendix E – LNG Cargo System P&ID 61

Project Members

The joint industry project consists of two main groups: The working group and the reference group. This project is funded by the members in the working group.

The Working group

The working group consists of six different companies: Swedish Marine Technology Forum, Linde Cryo AB, FKAB Marine Design, LNG GOT, White Smoke AB.

Swedish Marine Technology Forum is a non-profit organization that gathers the maritime industry in Sweden.The organization is working toward development of new and less environmentally damaging products, efficient production and cooperation between firms, universities and public representatives. Swedish Marine Technology Forum is also working to increase recruitment and enhance regeneration in the maritime industry.

The forum brings together the entire maritime industry in Sweden and its future challenges. The forum is addressed to the companies that is suppliers for the shipping, offshore and the leisure boat industry. Our members are engineering solutions, manufacturing, products and services in these areas.

Linde Cryo AB is one of the world's leading manufacturers of cryogenic equipment for the storage, transportation and handling of liquefied gases. We are an independent company belonging to the Linde Engineering Division. For more than 50 years we have put our skills and advanced technology at the service of the gas industry.

We are a speaking partner for most industrial gas companies when it comes to selecting the most efficient and economical cryogenic equipment.

CRYO AB is certified manufacturer of cryogenic pressure vessels with production according to several national and international approvals and standards, e.g. DNV, CE, ASME, ISO 9001.

CRYO AB's product line includes a large variety of LNG equipment, both on-shore and off-shore. The company's LNG programme includes complete LNG receiving terminals, semi-trailer for land transport, fuel tanks for ships and ferries, as well as gas supply back-up systems and mobile equipment for the testing of gas turbines.

Regarding LNG propellant systems for ships, CRYO AB has delivered more than 20 LNG fuel tanks with sufficient equipment in accordance with class rules. Ship types with these systems have been road ferries, PSV's and coast guard vessels.

FKAB Marine Design is a well recognized international consultancy firm who has delivered successful ship designs to ship owners and shipyards since 1961.

Our experience makes us an innovative and reliable design partner for any type of ship from the first sketch on a paper to complete production drawings.

In our portfolio of proven ship designs you find a great variety of designs ranging from a 6 m unmanned cable ferry to a 174 000 DWT cape size bulk carrier. We also supply our customers with all types of marine design related engineering services such as conversion design, ship stability, structural design, feasibility studies, project management, shipyard evaluations etc.

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LNG GOT, owned by Gasnor and Göteborg Energi, introduces LNG (liquefied natural gas) as fuel for ships in the port of Gothenburg. The goal is to deliver LNG from 2013.

Over the next decade significantly stringent environmental rules are expected for shipping. The emissions will be reduced significantly and it demands new alternative fuel for shipping. LNG is a very interesting alternative to current ship fuel. LNG reduces emissions dramatically compared to for example heavy fuel oil.

White Smoke AB is founded on the belief that developed shipping is an important and necessary part of the solution for the change into a more sustainable society. The company is a combined business development and consultancy company developing sound sustainable shipping business cases on its own behalf as well as for external clients. As a client to White Smoke AB you get an innovative and flexible business partner with profound knowledge how to create shipping solutions that combine "state of the art" environmental performance with a competitive cost level. White Smoke AB is also main owner of White Smoke Shipping AB, a recently established shipping company based on the same belief as White Smoke AB.

DNV is a global provider of services for managing risk, helping customers to safely and responsibly improve their business performance. As companies today are operating in an increasingly more complex and demanding risk environment, DNV's core competence is to identify, assess, and advise on how to manage risk. Its technology expertise and industry knowledge, combined with its risk management approach, have been used to manage the risks involved in numerous high-profile projects around the world.

Organised as an independent, autonomous foundation, DNV balances the needs of business and society, based on its independence and integrity. With its objective of safeguarding life, property and the environment, DNV serves a range of industries, with a special focus on the maritime and energy sectors. Established in 1864, the company has a global presence with a network of 300 offices in 100 countries, and is headquartered in Oslo, Norway. Its prime assets are the knowledge and expertise of its 8,000 employees from 98 nations.

The Reference group

Members of the reference group were specially invited in order to give best possible input to the project. The Reference group where summoned at certain occasions, such as workshops, reviews and presentations.

Reference group member companies are as follows:

- **Viking Line ABP**
- **Göteborgs Hamn**
- **Stena AB**
- **Topoil AB**
- **Fjordtank Rederi AB**
- **I M Skaugen**
- **SSPA Sweden AB**
- **Gasföreningen**
- **Transportstyrelsen**
- **Myndigheten för Samhällskydd och Beredskap**

Background

Our globe requires sustainable shipping and customers and cargo owners are demanding more environmentally sound transports. New regulations regarding ship emissions are at the horizon. Actions soon need to be taken; the question is only which direction to choose.

LNG (Liquid Natural Gas) as ship fuel is a good option to meet future regulations regarding SOx and NOx emissions set up by international authorities. In 2015 the allowed SOx (Sulphur oxides) emissions from ships sailing within ECA (Emission Control Area) will drastically be reduced. Since the sulphur comes purely out of the fuel, a change of fuel away from high sulphur fuels or a change to LNG will solve this problem. Low sulphur fuels will then most probably be more sought after and therefore possibly more costly, which will make LNG even more interesting as bunker fuel.

Then in 2016 the new NOx rules are put into force by the IMO (International Maritime Organization), which means very low levels of NOx emissions are allowed, the so called Tier III levels. This regulation only concerns ships built after the new regulations are put into force. With LNG as fuel it is possible to comply with these rules.

The environmental benefits of LNG are even higher than the aforementioned requirements. Today, particle and carbon dioxide emissions are not regulated for shipping. There are though many indications that restrictions will be introduced even in this area which makes LNG an even better alternative fuel for shipping. Since natural gas has the same components as biogas (a form of natural gas produced from renewable products), it is possible to switch LNG for LBG (Liquid Bio Gas). LNG can therefore also serve as a bridge to more use of renewable LBG.

Pictures from Gasnor

With LNG or LBG as ship fuel, there will be almost no emissions of SOx (sulphur oxides) and particles, very low emissions of NOx (nitrogen oxide) and reduced emissions of CO2 (carbon dioxide). If LBG is used the CO2 net value levels are very low.

LNG is a new product for us in Sweden and a distribution network is not currently structured. However, an intermediate storage facility for LNG is under construction in the Stockholm region and there are also plans for a similar LNG terminal in the Göteborg harbour.

LNG as bunker fuel is not a new invention though; today LNG is used as main propulsion fuel for some Nowegian ferries and offshore vessels. The bunkering is done by truck or directly from a shore based teminal, a proven technology that works well in Norway. This is not an alternative for larger ships though, where the LNG volumes are too large and the supply from a tanker truck would be too time-consuming.

A build-up of an LNG supply chain based on ship to ship bunkering instead is therefore of paramount importance for LNG to become a real alternative to Heavy Fuel oil and other bunker fuels. Nevertheless, there are no existing international guidelines for the procedure of ship to ship bunkering of LNG today.

This lack of formalities formed the project "LNG bunkering ship to ship" in order to develop an operational bunkering process and the technical solutions needed. The project is initiated by Svenskt Marintekniskt Forum and carried out together with FKAB Marine Design, Linde Cryo AB, Det Norske Veritas AS (DNV), LNG GOT and White Smoke AB.

LNG bunkering

Project objectives

This project aims at establishing a safe and time efficient ship to ship bunkering procedure for LNG, encompassing the entire bunkering operation, both the operational bunkering process and the technical solutions needed.

Since there are no existing guidelines for LNG bunkering ship to ship, the project will try to establish a foundation for an international standard and accompanying guideline for safe and time efficient bunkering of LNG.

The main objective of this project is for the outcome to be accepted and approved in principal by DNV.

Approval in principle by DNV, page 13

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LNG Bunkering Ship to Ship Joint Industry Project

DNV has participated in the above referenced Joint Industry Project which aims to develop a concept for bunkering LNG fuelled ships from a bunker ship. Our involvement in the project has been to facilitate a Hazard Identification exercise, to comment on the risk assessment and actions resulting from the HAZID and finally to evaluate the Project documentation from a Class perspective.

For vessels using LNG as fuel, the DNV Rules for Classification of Ships Part 6 Chapter 13 "Gas Fuelled Engine Installations" has requirements for bunkering system design and arrangement. For a Bunker Ship our Rules for Classification of Ships Part 5 Chapter 5 "Liquefied Gas Carriers" will apply. However, the bunkering operation as such is not covered by DNV Class Rules.

Currently the "Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships" is the only international statutory standard applicable to gas-fuelled ships. The IG contains requirements for bunkering system design and arrangement similar to Class Rules. Bunkering operations are indirectly covered by the requirement for a risk analysis of all ship operations. Hence, the acceptance of the risk analysis is the responsibility of the Flag State Administration, and is as such not a Class matter.

DNV has examined the LNG STS bunker solution documentation, including the HAZID documentation, procedure outline and technical solutions as developed in the case study for the vessels used in the project. Based on this examination, DNV's assessment is that the LNG STS bunkering solution proposed by the project is feasible within the framework of existing Rules and regulations.

Yours faithfully
for DET NORSKE VERITAS AS

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Head of Section
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Project Method

The bunker scenario

The Ro-Pax vessel sailing in short sea shipping is highlighted as a suitable user of LNG as main fuel. The bunkering of such a ship is used as reference throughout this project.

It is assumed that the bunkering will take place in a port very close to urban areas and that the Ro-Pax ship has short turnaround time, approximately one hour. This means that the requirements on the ship to ship bunkering are strict both for bunkering speed as well as for safety aspects.

For a Ro-Pax ship the time schedule is of most importance. Therefore, in order not to prolong the stay in port, the bunkering operation has to be carried out during unloading and loading.

In most cases the LNG fuelled ship will need both LNG and some type of diesel oil for propulsion. Either the ship has both pure gas engines and pure diesel engines for redundancy issues. Either the ship uses dual-fuel engines, an engine that uses small amounts of diesel to ignite the gas. In both cases LNG and diesel oil are used as bunker fuels. Focus has been on providing both bunker fuels at the same time from one bunker ship.

The amount of LNG bunker fuel needed for this scenario is set to 130 m3 = 65 ton. The maximum bunkering time including mooring is set to 50 minutes.

For other types of ships on different routes other amounts are of course needed.

Risk Assessment

Safety is of great importance for the use of LNG as bunker fuel. As a point of departure the project group carried out a hazard identification workshop (HAZID) led by DNV. The working group as well as the reference group participated in the workshop. The HAZID workshop identified the different risks that should be accounted for and taken care of during a LNG ship to ship bunkering procedure. Since this workshop was conducted early in the project phase, its outcome served as input to the concept development.

The purpose of this exercise was to identify additional risks by using LNG in a port environment. Each identified risk was rated by frequency and consequence and documented with comments regarding operational and technical solutions.

When the HAZID was completed and the report delivered from DNV the risk assessment work started along with the concept study. During the risk assessment work new risks that came up were added and taken care of. All risks addressed were accounted for and actions how to handle these are directly implemented in the bunkering procedure and the technical concept development.

In order to achieve the complete risk identification for LNG bunkering in a certain harbour a complete risk assessment for the harbour needs to be conducted. The risk assessment of this project could serve as input for such an investigation.

Rules and Guidelines

During bunkering there are certain regulations to consider. Local authorities and the responsible port need to permit LNG bunkering at the chosen location. In this study the following national rules and guidelines has been used:

- Port Regulations for the Port of Göteborg
- Sea Regulations from the Swedish Transport Agency, Maritime department
- Land Regulations from the Swedish Civil Contingencies Agency (MSB)

For the two ships involved in the bunkering operation there are two set of rules:

- IMO IGC Code – (International Gas Code), Rules for the bunker ship
- IMO IGF Interim guidelines – (International Gas Fuel), Rules for the receiving ship

The IMO IGC Code is the international regulation for gas carriers and will therefore be valid for the bunker ship. For the receiving vessel, the ship using LNG as bunker fuel, the IGF interim guidelines are the regulations that have to be used. The IGF guidelines are called "interim" since they are not yet finalized. The IGF guidelines will, according to plan, be finalized during 2012. Hopefully the content of this work could supply the IMO via the IGF working group called BLG (Bulk Liquid Gases), with information and solutions in order to implement bunkering in the future IGF Code. With international standards about ship to ship bunkering, systems can be more effectively enforced and the LNG fuel supply logistics can be more widely spread.

Ship to Ship bunkering of LNG is a form of LNG transfer and therefore SIGGTO, *Society of International Gas Tanker & Terminal operators Ltd,* guidelines has been considered. The SIGTTO guidelines are focused on large scale LNG transfer from LNG carriers, both for transfer to terminal and for Ship to Ship LNG transfer. Though these guidelines are for large scale LNG, many of the aspects could be used within the LNG bunkering ship to ship project.

The bunker scenario of this study includes transfer of both LNG and diesel oil from one ship to another. Therefore the SIGGTO as well as the OCIMF, *Oil Companies International Marine Forum,* guidelines need to be accounted for within the work of the study. The set up of the bunkering procedure described in the Appendix is based upon the OCIMF guidelines considering oil bunkering, in order to get an internationally accepted structure to the document.

During the risk assessment and the concept development, DNV has provided the project with vital information from the class society point of view.

The Results

The main aim with this project has been to establish a safe and time efficient ship to ship bunkering procedure for LNG, encompassing the entire bunkering operation, with both the operational bunkering process and the technical solutions that are needed. The bunkering procedure presented in the text below meets this requirement and the complete concept is accepted and approved in principle by DNV.

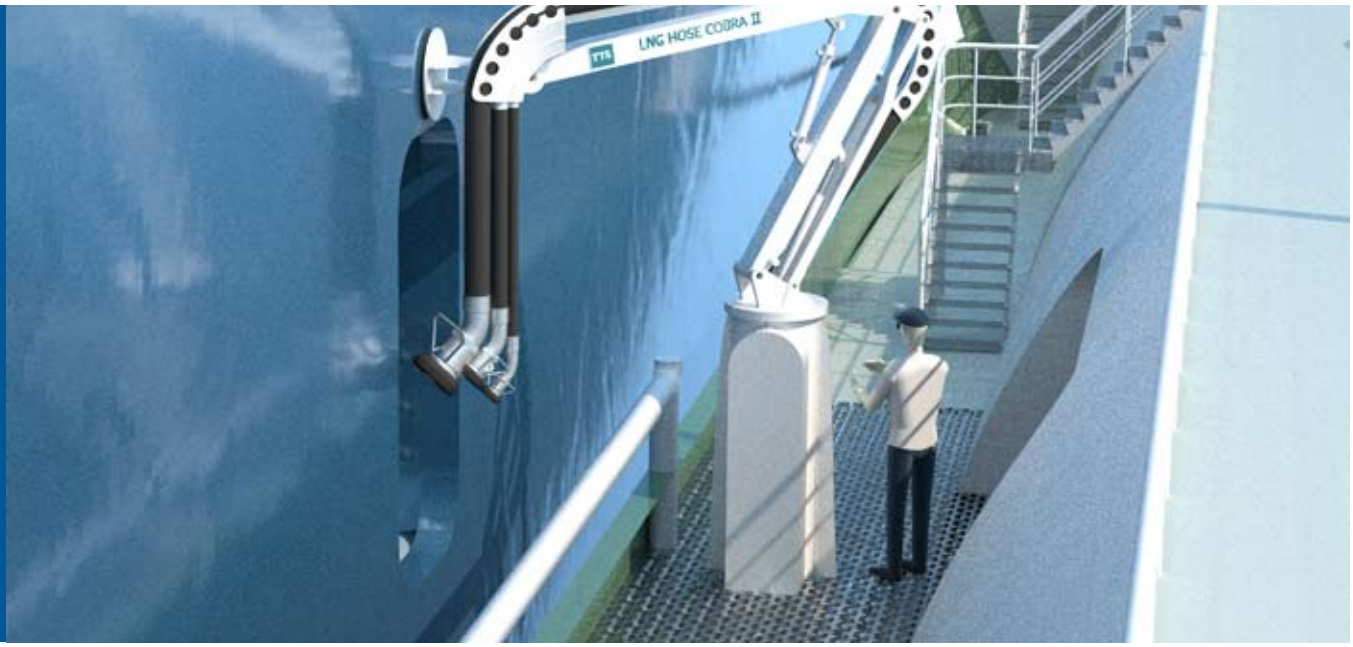
This procedural description over the LNG ship to ship bunkering can be used by authorities and others as input to regulation and guideline work concerning LNG bunkering. The project has already been acknowledged by Swedish authorities who will use it as input to their work. The class society Germanischer Lloyd (GL) has also showed interest in the project, they will carry on with a similar project called BunGas which uses the knowledge from the LNG bunkering ship to ship project.

This study has showed that LNG bunkering ship to ship is indeed a suitable solution to provide environmentally friendly bunker fuel to larger ships which hopefully will open for more utilization of LNG or LBG in shipping.

In order to produce a description which was general to fit many needs and different bunkering cases, certain technical solutions which have been developed during this project are not included in the bunkering procedure such as; The hose handling crane and the fact that pumping of LNG from the bunker ship can be done without using pumps.

The hose handling crane

Among the first issues that were discussed in the risk assessment, was LNG hose handling and the risk for hose damage. The hose handling needs to be very accurate and fast, in order to comply with the bunkering scenario, therefore a hose handling crane was discussed. The company TTS, which has shown a great interest to this project, promised to help us design this hose handling crane.



Picture of TTS Hose Cobra II

This hose crane can handle all hoses described in the bunkering procedure. The crane connects to the hull side of the receiving ship via a vacuum suction system, in that position the hoses are very easily reached from the bunker port. When the crane is connected to the hull side, the hydraulic system is released which enables the crane to follow all ship movements.

Pumping of LNG using pressure instead of pumps

A LNG tank can be emptied using a high pressure inside the tank instead of using a pump. This fact made CRYO to investigate if an increased pressure in the LNG cargo tank could transfer the LNG at the same rate as with a normal cryogenic deep-well pump. Technically this is a very interesting solution and according to CRYO, even higher transfer rates can be achieved using the method.

The system demands that both the cargo tank and the receiving bunker tank can handle a high pressure of approximately 10 bar. There is also an increased risk of unwanted release of methane via the safety valves due to the high pressure. Nevertheless it is a interesting solution which CRYO will investigate more thoroughly.

Preface – LNG bunkering ship to ship procedure

This procedure is made for ship to ship bunkering of LNG in a port environment, with a dedicated bunker ship delivering the fuel to client ships. LNG bunkering ship to ship in port with demands for short operation time have not been performed before and this procedure has been worked out to handle the specific details of this operation in a safe way.

The procedure is based on existing guidelines for LNG and petroleum ship-to-ship transfers together with the result from the HAZID exercise and risk assessment work described above.

This procedure is divided into chapters describing different aspects of the process :

- Chapter 1-4 refers to conditions for bunkering LNG and petroleum
- Chapter 5-7 refers to the Bunkering process
- Chapter 8-10 refers to system and equipment description
- Chapter 11-12 refers to emergency operations and Gas handling

The procedure is made for both transfer of liquefied gases for propulsion purposes (LNG) and petroleum, simultaneously or one fuel only. The parts of the procedure which are specific for LNG, or for petroleum, are clearly marked in the caption to each sub-chapter.

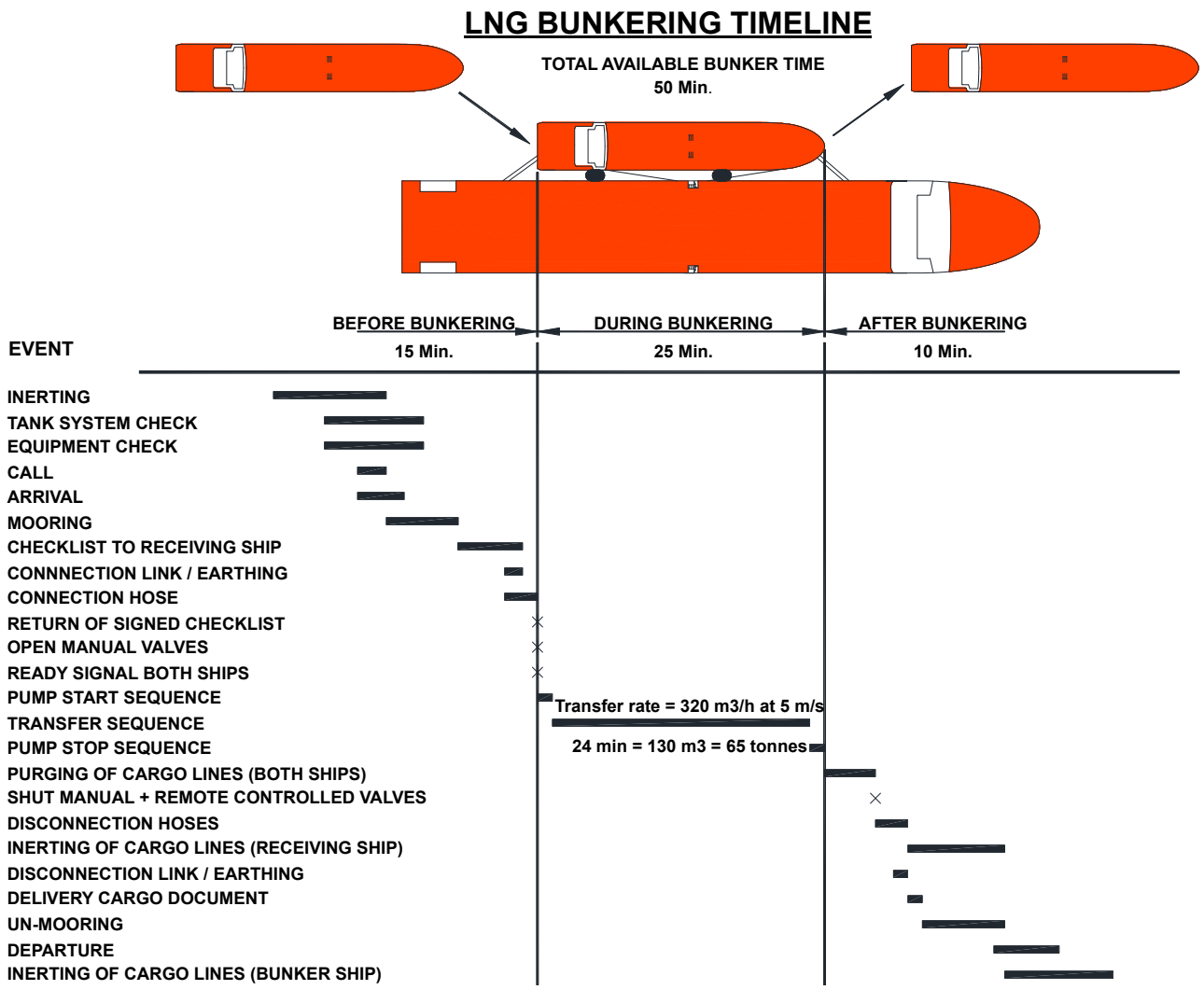
This is a general description of a bunkering process and can only be used as a guideline for future bunkering projects. For dedicated ships there may be additional technical and/or operational solutions which can enhance safety and shorten the bunkering time.

Bunkering ship to ship today

Bunkering Timeline

The timeline used in this project is presented in the picture below.

The time limit for the bunker scenario is set to 50 minutes for the complete bunkering ship to ship procedure. In order to more easily distinguish the different actions during the bunkering operation the procedural description is divided in three stages: Before, During and After bunkering. These stages are described more thoroughly in the following text.



Glossary

Bunker Ship
A ship which transfers liquefied gases to another ship for propulsion purposes.

Bunkering Area
Defined area on both ships around bunkering station on the receiving ship and manifolds on the bunker ship.

ESD
Emergency Shut-Down. The functions of the ESD-system are to stop the liquid fuel and vapour flow in the event of an emergency and to bring the bunker handling system to a safe static condition.

EX-Zone
Area in which all electrical equipment has increased safety level and the electric energy too low to avoid ignition of LNG vapour.

IGC Code
IMO International code for Gas-Carriers

IGF Code (Interim)
IMO International code for Gas-Fuelled ships. Interim version.

IMO
International Maritime Organization.

LNG
Liquefied Natural Gas. Predominantly methane (CH4) which has been cooled down to approx. -162 deg. C and converted to liquid for easier storage and transportation.

MDO
Marine Diesel Oil is a blended fuel from gasoil and heavy fuel oil.

MGO
Marine Gas Oil is a fuel made from distillates only.

Receiving Ship
A ship which receives liquefied gases from another ship

RPT
Rapid Phase Transition is a phenomenon when LNG vaporizes violently in contact with water.

SECA
SOx Emission Control Areas are defined areas with restrictions regarding the amount of sulphur in the fuel.

Secondary Fenders
Secondary fenders are used for preventing contact between the ships when rolling.

1 GENERAL PRINCIPLES

1.1 Scope

This procedure is made for ship to ship bunkering of LNG in a port environment, with a dedicated bunker ship delivering the fuel to client ships. The described bunker operation in this procedure is based on common petroleum and liquefied gas transfers with regards to the specific regulations for LNG within IMO IGC codes and interim IGF codes and technical solutions for safe short time bunkering.

1.2 Control of operations

On each ship there must be one responsible person in charge during the complete bunker operation. This person is to have sufficient education, training and authorization to safely perform the LNG bunkering.

1.3 Responsibility

Each Master is responsible for his own ship, personnel and bunker regarding all safety and other issues for the complete operation. All bunker operations must be agreed upon between the bunker ship and the receiving ship before commencing any actions.

LNG Bunker Ship (Example)

2 CONDITIONS AND REQUIREMENTS

2.1 Approval

Before commencing any bunker operations it is necessary to have Authorities approval for LNG bunkering and to check the local regulations and get approval from the port in which the transfer is planned to be carried out.

2.2 Ship Compatibility

It must be clarified that mooring and bunker equipment are compatible in design so that the bunker operation can be conducted in a safe way before commencing any operations. Following points are to be confirmed by communication :

- Possibility for safe mooring
- The relative freeboard difference (see 6.5 fig.3)
- Type and size of hose connections
- Connection order of the manifolds

Recommendation: Use recommended mooring plan (see 5.3.2) and couplings (see 8.1.4).

2.3 Transfer Area

The transfer area is determined by the local port and approved by authorities (see 2.1). The approaching bunker ship is to check and evaluate if the area is suitable for bunkering operations. The operation should be aborted if there are issues that can compromise a safe transfer.

Points to be considered are:

- Manoeuvring space
- Tidal conditions
- Traffic density
- Waves, swell and weather conditions (see 2.4)

2.4 Weather Conditions

Weather and current forecast for the area are to be studied before commencing bunkering operation. Each Master is responsible for his own ship and bunkering is only allowed when both Masters agree that ambient conditions (like wind and weather) are acceptable. Each Master is also responsible to determine restrictions and take actions in case of a sudden change of ambient conditions during a started bunker transfer.

2.5 Light Conditions

The bunkering operation is preferably to be conducted during daylight hours.

It is necessary to have adequate lighting in case of mooring and bunkering operations after daylight hour. The minimum lighting requirements are the bunker ship deck, the receiving ship bunker station and the mooring bollards (see 8.6).

Take notice of weather conditions

3 SAFETY

3.1 General

Each Master is at all time responsible for the bunker operation and should not allow safety issues to be influenced by the actions of others. Each Master is to ensure that correct procedures are followed and that internationally accepted safety standards are maintained and that the ship design is according to approved rules and regulations.

3.2 EX-Zone

The bunkering areas on both ships are to be an EX-classified and restricted area during bunkering. Only authorised personnel is allowed in these areas during bunkering. Inside the EX-zone all electrical equipment requires increased safety level and the electric energy should be too low to avoid ignition of LNG vapour. The size of the EX-zone shall be according to class rules for gas-dangerous space and 10 m horizontally on each side of the receiving ship bunker station + the whole shipside vertically.

3.3 ESD-System

Each ship is to have an independent Emergency Shut-Down system for a quick and safe shut-down in case of an emergency. The system is described in chapter 10 and 11.6.3.

3.4 Check-Lists

Each ship is to have internal check-lists for before and after bunkering.

For bunker operation there shall be a common check-list which is to be filled out and signed by responsible operators on both ships before any operation is commenced.

See 5.2, 5.9, 7.9 and appendix A-C.

3.5 Instructions (Routines)

There shall be written detailed instructions for the bunkering process on both ships with regards to responsibility and actions to be made in case of malfunction or emergency. The instructions are to be quickly available at all times and all personnel involved in bunkering operations are to be familiar with the content and location of the instructions. The instructions should cover the following areas:

- Loss of communication or control system (ESD)
- Loss of power
- Safe break-away of ships in case of fire
- Handling of cryogenic and petroleum products including use of personal protection equipment, ice formation and awareness of sharp edges.
- Waves and weather conditions (see 2.4

3.6 Warning signs

There shall be warning and instruction signs posted around hazardous area on both ships. The signs are to be placed clearly visible and according to an accepted guideline for placement of warning signs. The warning signs are to cover the risks of handling cryogenic liquid, fire and safety issues and show restricted areas.

3.7 Safety during Bunker

3.7.1 Smoking and Naked Light

Regulations regarding smoking and use of naked light should be strictly enforced. Warning signs and notices shall be displayed and smoking rooms are to be designated and clearly marked.

3.7.2 Earth on switchboard

The main switchboard on the bunker ship and the control panel on the receiving ship are to have earth indicator lights to indicate faulty circuits.

Any indications of faulty circuits are to be immediately traced and isolated to avoid arcing around bunker area. The bunkering operation is to be suspended in case of faulty earth indication during ongoing transfer.

3.7.3 Electrical Currents

Electrical current and Electrostatic Charge in Bunker Hose

To prevent the occurrence of arcing between the ships the manifolds on both ships are to be earthed, all hoses are to be electrically continuous and each hose string shall be fitted with an insulating flange on the bunker ship manifold. It is important that the insulating flange only is fitted to one ship; otherwise there may be an electrostatic build-up in the hose between the insulating flanges which can result in arcing.

Electrical Arcing

Other places (besides hose connections) where arcing can occur are:

- Mooring lines (Should be insulated)
- Ladders or gangways between ships (Should be insulated)
- Crane wire runners and hooks (Careful operation)
- Bare wires and chains for fender support (Should be insulated)

3.7.4 Radio and Communication Equipment

The ships main radio transmissions may cause electrical resonance in insulated parts of some ship fittings arcing such as mast stays and this can cause arcing across deck fittings. Radio aerials should be earthed, but can induce arcing if insulators are coated with salt, dirt or water. The use of ships main radio equipment during transfer operations can be dangerous and should be restricted during the process. The equipment is not to be used if there is possibility of flammable gas in the vicinity of the antennas.

Satellite communication equipment normally operates at low power levels and is considered to be a low ignition hazard. The equipment is not to be used if there is a possibility for flammable gas in the vicinity of the antenna.

VHF and UHF communications are low voltage operated and are considered to be safe to use. Hand-held VHF or UHF radios are to be intrinsically safe (EX-class)

Portable electronic devices such as mobile phones, cameras etc using batteries are not allowed in hazardous areas unless they are EX-class. It is especially important for personnel working in or visiting such areas to be aware of this.

Warning/notification signs are to be posted around these areas.

Recommendation: Use VHF communication (see 4.2 and 5.3)

3.7.5 Radar

The radar equipment is not intrinsically safe and can create potentially hazardous power densities, especially since the bunker ship normally is smaller and the radar will sweep across the receiving ship hull at close range. The radar on the bunker ship is to be turned off after the mooring sequence and not switched on before the unmooring sequence starts, unless required by special demands.

3.7.6 Electrical storms

No bunker operation should be commenced during electrical storms. In case of sudden electrical storm appearance during ongoing transfer, the operation is to be suspended and all systems secured until it is considered safe to resume operation.

3.7.7 Fire-Fighting Equipment

Fire-fighting equipment on both ships are to be ready for immediate action.

Foam and water monitors on the bunker ship to be pointed towards the bunker manifolds in use and the bunker station fire system should be activated on the receiving ship.

3.7.8 Accommodation Openings

All accommodation openings on the bunker ship are to be closed during transfer.

Personnel transit is only allowed through designated doors which are to be closed immediately after use. Restrictions for receiving ship see 3.7.9

3.7.9 Safety Zone

Since the receiving ship normally is larger than the bunker ship is it important to have a safety zone above the bunker station during bunkering. The extent of the safety zone should be 10 metres on each side of the bunker station manifold.

This safety zone shall be clearly marked and have the following restrictions:

- No unauthorised persons to be able to access open deck areas directly above the bunker area
- Warning signs to be posted around the area
- Access doors to be locked and only to be opened by trained and authorised personnel
- No overhead crane lifting in this area during bunkering
- No maintenance work in the area during bunkering
- No manoeuvring of ship equipment in the area during bunkering
- Ventilation inlets in the area to be closed during bunkering

3.7.10 Gas Accumulation

Transfer operation shall be suspended if there is fuel vapour leaking around manifolds on either ship. Operation is not to be resumed until leakage is identified and stopped and all gas has dispersed which is monitored by gas detectors at both ships bunker stations (see 8.8).

3.8 Maintenance

Key components in both ships systems are to be identified with emphasis on safety to avoid leakage and ignition sources in and around the bunker areas. These components should have a maintenance and replacement schedule where inspections and actions are documented and stored on board.

3.9 Redundancy

Key components in both ships control and power systems is to be identified with emphasis on safety in case of failure. These components shall have redundancy back-up which can start up within a short period of time.

Gas-fuelled Ro-Ro Ship (Example)

3.10 Personnel education and training

All personnel working with LNG bunkering is to be educated, trained and authorised for working with liquefied gases. Non-educated and trained persons are to be classified as unauthorised and are therefore not allowed to be inside bunker area during operation. Education and training records of all personnel are to be kept on board and be available if requested by port, authorities or the other ship. Regular safety drills regarding fire, smoke and the handling of loss of communication should be performed and documented according to ISM (International Safety Management) Code 2002 by IMO. (See also 11.5)

3.11 Personal protection equipment

There shall be personal protection equipment, like gloves, eye protector and protective clothing, for handling cryogenic products at bunkering areas on both ships and the personnel involved are to be well instructed where to find the equipment and how to use it. There should also be medical treatment facilities on board and knowledge how to handle minor injuries from cryogenic products.

3.12 Sharp edges

Both ships shall be designed not to have any sharp edges around the bunker stations due to the possibility to damage the hoses during handling. Loose items with potentially sharp edges, like hand tools, are to be stored outside the direct hose handling area.

4 COMMUNICATIONS

4.1 Language

The English language shall be used for communication. Communication phrases should also follow common standards, for example *Standard Marine Communication Phrases* (IMO) for the English language.

4.2 Communication between Ships

The communication methods used could be by VHF, hand-held radios, vocally or by a separate communication link depending on the phase of the operation and availability of equipment. There shall also be reliable means of communication at all times during mooring and bunkering, such as hand-held VHF. No mooring or transfer operation are to begin before effective communication has been confirmed. Optionally there can be a cable link between the ships containing a wired communication system between bunker stations (see 5.6)

Recommendation : Use VHF or a communication link (optional) (see 3.7.4 and 5.3)

4.3 Procedure for Communication Failure

Communication failure during approach – Abort approach and re-establish contact before attempting a new approach.

Communication failure during bunker operations – Sound the emergency signal and suspend all operations in progress immediately.

Operations shall not be resumed before communications has been re-established.

Communication Equipment (Example)

BUNKER PROCESS CHAPTER 5-7

5 OPERATIONS BEFORE BUNKERING

5.1 Preparations

The following steps shall be made prior to start of the operation and noted on the Before bunker check-list:

- Safety zone on receiving ship (see 3.7.9) activated and checked.
- Fire equipment on both ships checked and ready for use (see 3.7.7)
- Personal protection equipment on both ships checked and prepared for use (see 3.11 and 12.2.6)
- ESD system on both ships checked and ready for use (see chapter 10)

5.1.1 LNG Tank System Check

Both ships must check the LNG tanks regarding temperature and pressure prior to bunkering and note this on the pre-transfer bunker checklist (see 5.2 and appendix B). If the temperature of the receiving tank is significantly higher than the bunker tank, there will be an initial vapourisation when starting to transfer the LNG. This will increase the tank pressure and can trigger the pressure relief valve to open if the pressure exceeds the set limit. The pressure of both tanks must be reduced prior to the bunkering in case of a high receiving tank temperature.

The bunker ship Master is to confirm that both ships combined temperature and pressure range are within the safety limits before commencing transfer.

Recommendation : The use of a communication link (optional) will make it possible for the bunker ship to monitor the receiving ship's tank online for increased safety reasons (see 5.6)

5.1.2 Mooring Equipment Check

Lines, fenders, winches and other mooring equipment is to be visually checked for wear or damages. Equipment should be replaced or mooring aborted if there are any doubts about equipment quality and safety.

5.1.3 Bunker Hose Check

Bunker hoses are to be visually checked for wear or damages and that the hose markings are correct for the actual transfer operation (see 8.1.6). Bunker hoses should be replaced if there are any doubts about equipment quality and safety.

5.1.4 Oil Bunkering

There are some specific points to address before performing bunkering oil, such as:

- Deck scuppers in bunker area to be closed
- Sea and overboard discharge valves to be closed and sealed
- Bunker tank lids to be closed
- Ullage ports to have proper flame screens

See Appendix B for Check-list "Pre-Transfer Bunker"

5.2 Check-List Before Bunker

Both the bunker ship and the receiving ship is to have a checklist which contains steps to be made and documented specific for each ship before the bunkering process commences.

See Appendix A for Check-list "Before Bunkering".

5.3 Call

The discharging ship calls by the normal VHF contact channel and request for permission to berth. Working channel for VHF communication, emergency signal (see 11.1) and contingency plan (see 11.3) to be agreed upon.

5.3.1 Safe Communication

Safe communication and the possibility of performing bunker operation, due to weather and traffic conditions according to chapter 2, is to be confirmed by officers on both ships.

5.3.2 Mooring Plan

The receiving ship should be able to supply, if requested, a sketch with information about placement and number of fairleads and mooring bitts and their relative distances to the bunker station. A mooring plan, showing number of lines and fenders and their locations should be agreed upon before making berth.

Recommendation : The receiving ship should have mooring bollards placed according to 5.5.3 fig.1.and use a new standardised mooring plan for safety and time saving reasons

5.4 Manoeuvring

After permission to berth is granted, the approach manoeuvring can commence.

A constant monitoring of weather conditions (see 2.4), waves and swell (see 2.3), tidal conditions (see 2.3), surrounding traffic positions (see 2.3) and receiving ship movement is to be performed during approach.

5.5 Mooring

5.5.1 Fender Positioning

Minimum two main fenders to be rigged alongside according to 5.5.3 fig.1 before berthing with the receiving ship. Secondary fenders to be placed to the extent that no part of the bunker ship can come in contact with the receiving ship.

5.5.2 Fender Type and Size

It is recommended to use pneumatic type main fenders with a diameter of approx. 1 metre. Size and type of secondary fenders to be determined due to the design of the bunker ship. All fenders to be approved by class.

5.5.3 Mooring Operation

When taking weather conditions such as wind and current in account (see chapter 2), the bunker ship is to manoeuvre alongside the receiving ship in a safe way.

Mooring is completed when all mooring lines are connected according to the mooring plan and tensioned to ensure that the bunker ship is safely secured to the receiving ship.

Lines should only be led through class approved closed fairleads.

Two mooring bollards should be placed on a distance within 6-9 metres on each side of the receiving ship's bunker station, Two more bollards should be placed to the forward part of the ship and two bollards to the aft. part of the ship.

All bollards to be at approx.the same height as the receiving ship's manifold. The bunker station should be placed on the flat part of the shell to ensure a good mooring possibility.

Additional lines to should be ready for use if needed.

Fig.1 - Typical Bunkering Mooring Arrangement

5.5.4 Mooring Lines Supervision

Mooring lines are to be under supervision during the operation. Special attention is to be given when bunkering a vessel with loading and unloading of heavy vehicles which can cause rapid vertical movement on the receiving ship.

5.6 Connection Communication Link (Option)

Optionally, there can be a separate cable link which is handed over and connected to the receiving ship (see 4.2). This link could contain a wired communication system with the possibility to:

- Have a direct line phone system
- View the level, temperature and pressure of the receiving tanks
- Monitor alarms on both ships.
- Include the emergency stop control instead of a separate box (see 11.2 + 11.6.3)

Both ships must have the same interface to be able to connect and communicate.

Recommendation : The use of a communication link for increased safety reasons.

5.7 Connection of Hoses

Dedicated bunker ships may be fitted with specialised hose handling equipment, but a rather common way would be to use a hose crane to deliver bunker hoses from the bunker ship to the receiving ship.

The hoses are to be supported to the receiving ship (see fig.2), disconnected from the hose crane and connected (see 8.1.4) to the manifold, by trained personnel from the receiving ship, before operation commences.

Each manifold are to be earthed and the receiving ship shall be equipped with an insulating flange near the coupling to prevent a possible ignition source due to electrostatic build-up. The hoses with couplings should not touch any un-earthed part before connection to avoid possible electrical arcing.

The hose connections can, if possible, be of different sizes for increased safety reason.

5.8 Bunker Hoses

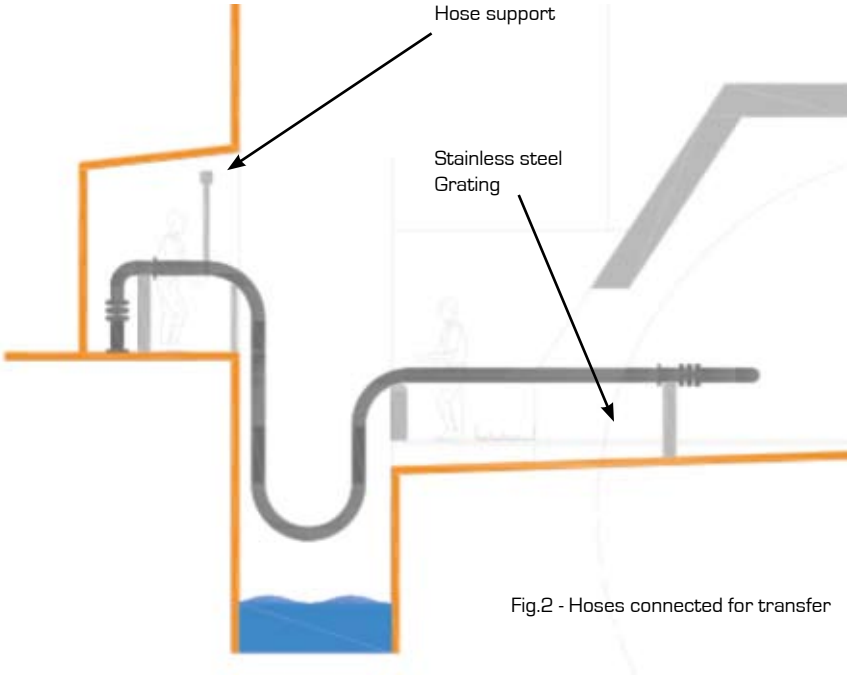


Fig.2 - Hoses connected for transfer

5.8.1 LNG Bunker Hose and Vapour Return Hose

One or two flexible hoses will achieve the connections between the two ships; one liquid filling hose and one vapour return hose if needed.

The LNG bunker hoses are to be clearly colour-marked according to a defined system so that there will be no risk of using an incorrect hose type. (see 8.1.6) The hose shall be visually checked and to be well within the last replacement date prior to all transfer operations (see 8.1.5). Hoses must be in good condition, have suitable size and length for each specific transfer and supported to avoid overstressing or chafing during transfer. Preferably the number of different hoses is to be kept to a minimum.

Normally the hoses are laying in a bow on the bunker ship tray grating during the transfer and must not come in contact with the steel deck.

It is important to make sure the hoses does not come in contact with the water if arranging the hoses in bow overboard (see fig.2)

For bunker hose details – see chapter 8.1

5.8.2 Oil Bunker Hose

The oil bunker hoses are to be clearly colour-marked so that there will be no risk of using an incorrect hose type (see 8.1.6). The hoses must be in good condition, have suitable length for the actual transfer and supported to avoid overstressing or chafing during transfer (see 8.1.5).

For bunker hose details – see chapter 8.1

5.9 Pre-Transfer Bunker Check List

The pre-transfer checklist is a mutual document with steps to be made on each ship and signed by authorized persons to confirm that all points are addressed. The bunker ship operator is responsible for the checklist to be properly filled in and signed before delivery to the receiving ship.

(see 6.1.1 + Appendix B)

6 OPERATIONS DURING BUNKERING

6.1 Return of Documents

6.1.1 Signed Check-List

The pre-transfer bunker check-list (see 5.9 and appendix.B) is to be filled out, signed by the responsible operator on the receiving ship and returned to the bunker ship before starting any transfer. The signed check-list is to be kept on board the bunker vessel for 3 months.

No bunker operation is to begin until this check-list is signed and returned to the bunker ship.

6.1.2 Signed document with Agreed Amount and Transfer Rate

A document, clearly stating the quantities of fuel to be transferred, the transfer rate, start and topping up rate and max. pressure at manifold, is to be filled out and signed by the responsible officers on both ships. This document can be combined with the pre-transfer check-list mentioned above (see appendix.B). The signed document is to be kept on board the bunker vessel for 3 months

6.2 Open Manual Bunker Valves

After receiving signed documents according to 6.1 it is allowed to first open the manual bunker valves. It is important to check that the remote controlled bunker valves are closed, by visually checking the valve indicator, prior to opening the manual valves.

6.3 Ready Signal Both Ships

When the manual valves are confirmed to be opened and the personnel is confirmed to be outside the immediate transfer zone, both ships confirm that they are ready to commence bunkering by giving a ready signal by VHF or optional communication link.

6.4 Pump Start Sequence

After ready signals are given and personnel are out of the bunker area, the cargo pumps can be started and ramped up in a controlled manner until the agreed start transfer rate is achieved. This sequence is to be closely monitored on both ships for possible leaks, hose and equipment behaviour and system functions. If any problems, or suspicions of problems, are detected, transfer is to be shut-down immediately and not started again until satisfactory checks and actions are performed. The start sequence transfer rate is to be upheld for an agreed time, giving time for monitoring and also cooling down of the system (only for LNG) before the transfer.

This procedure is to be performed for each tank to be filled regardless of fuel type.

6.5 Bunkering

When the pump start sequence is completed without remarks, the cargo pumps can continue to ramp up in a controlled manner until agreed rate (see appendix B) is achieved under constant supervision and monitoring of the equipment and the system. This rate can be withheld during the transfer until agreed amount is almost reached. The transfer is to be monitored on both ships with regards to system pressure, tank volume and equipment behaviour.

This procedure is to be performed for each tank regardless of fuel type.

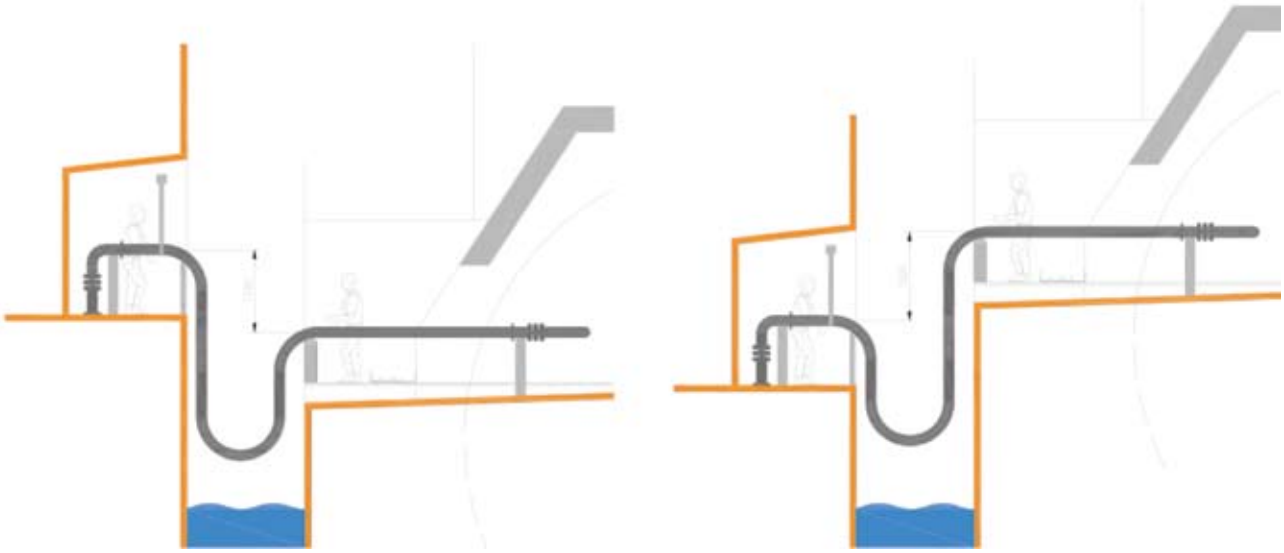


Fig.3 - Max. relative freeboard movement (Example)

6.6 Pump Stop Sequence

The cargo pumps shall be ramped down to an agreed topping up rate (see appendix.B) when the total transfer amount is almost reached. The final filling requires special attention on the receiving ship to watch tank level and pressure. Note that the max.level for filling the LNG tanks is 98% of total volume according to class rules, but is normally lower for system design reasons. The receiving ship operator is to signal, by VHF or optional communication link (see 5.6), to the bunker ship when the required amount of fuel is reached. The bunker ship will then stop the cargo pumps.

This procedure is to be performed for each tank regardless of fuel type.

7 OPERATIONS AFTER BUNKERING

7.1 Purging of Bunker Hoses

The liquid that remains in the bunker hoses, after the pumps have stopped, must be drained before disconnection. Heated LNG-vapour (GNG) from the bunker ship is to be blown through the hose in order to purge the hose. The valves, nearest to the manifold connections on both ships, are to be closed when the purging is completed.

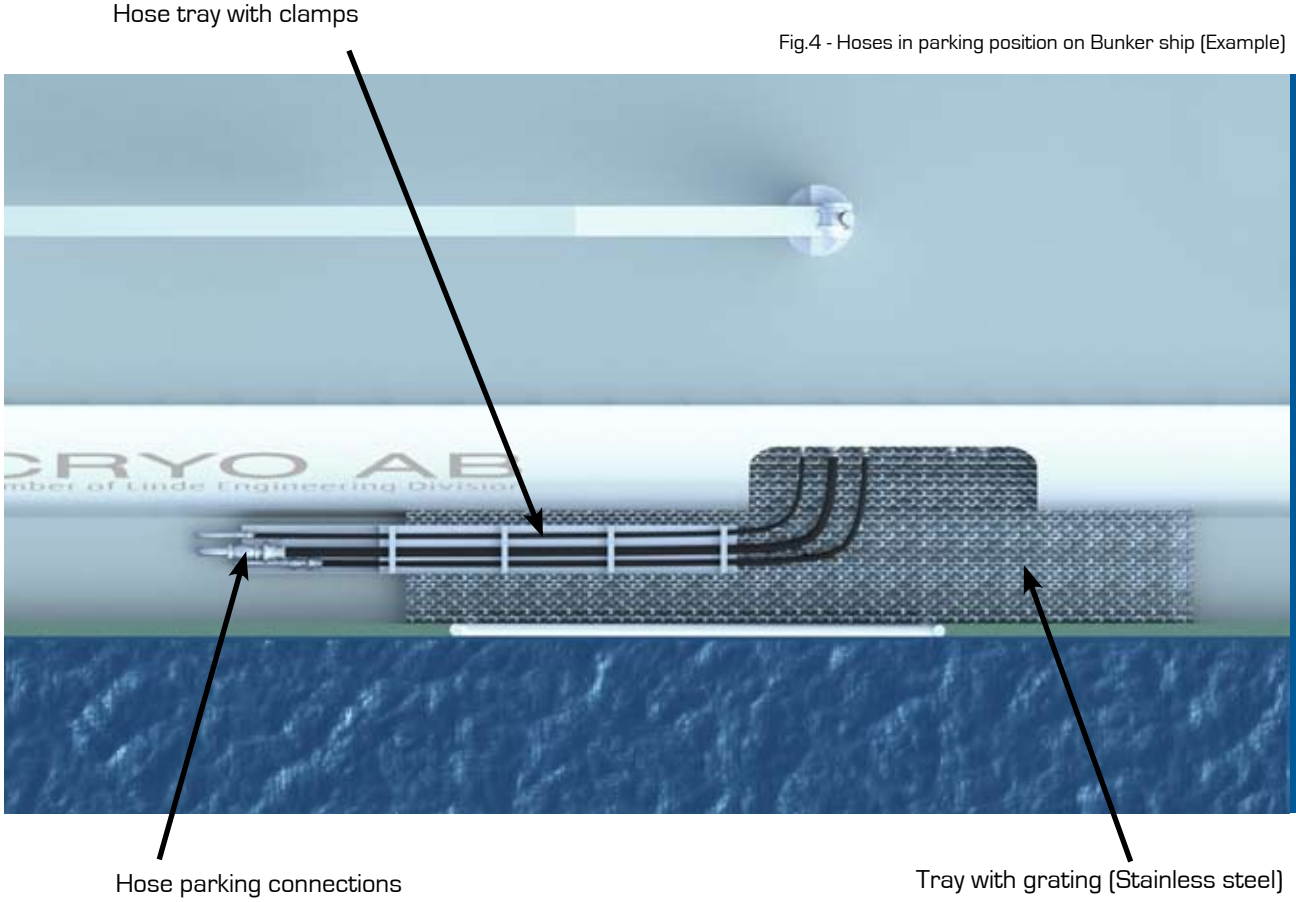
7.2 Close Manual and Remote controlled valves

The valves, at both manifolds, are to be closed when the hoses are purged.
First the remote controlled valves are to be closed and then the manual valves.

7.3 Disconnection of Hoses

The bunker lines and vapour return, on the receiving ship, can be disconnected after the lines have been purged from liquid and valves are closed. With use of protective equipment (gloves and protective clothing), the quick-connect couplings are to be disconnected with attention to possible dripping of fuel. The hoses are to be connected to the bunker ship hose crane and made loose from the support in the receiving ship. The crane returns the hoses to the bunker vessel where they are put in their parking position, clamped and connected to ventilation mast. There should not be any sharp edges in the hose handling area (see 3.12).

Fig.4 - Hoses in parking position on Bunker ship (Example)



7.4 Disconnection Communication Link (Option)

The communication link, if available, is to be disconnected and returned to the bunker ship.

7.5 Delivery Bunker Document

The bunker ship is to deliver a document, in 2 copies, clearly stating the quantity and quality of fuel transferred, signed by the responsible officer. Both copies are to be signed by the receiving ship personnel. One signed document is to be kept on board the bunker vessel and the other document on board the receiving ship 3 months

7.6 Unmooring

After transferring documents, the unmooring sequence can begin. The mooring lines are loosened, drawn back and stored, under supervision of the responsible officer while taking wind and current conditions into account. The fenders are to be retracted and stored when the bunker ship has safely moved away from the receiving ship. The radar is to be activated before departure.

7.7 Manoeuvring

The bunker ship must have constant monitoring of surrounding traffic positions during unmooring and departure.

7.8 Inerting of Bunker Lines

The receiving ship must inert the bunker lines before departure, which means that the inerting sequence is to start as soon as the hoses are disconnected from the manifold and run until lines are gas free. The bunker ship does not need to inert before departure since the hoses are connected to the hose parking and are ventilated. The inerting process can be done after departure from the receiving ship. To avoid the risk of forgetting to inert the bunker hoses, there shall be an inerting section in the after bunker check-list to be checked out within 10 minutes after departure and an alarm signal on the main switchboard if inerting valve has not been activated within 60 minutes from stopping the cargo pumps.

7.9 Check-list After Bunker

Both the bunker ship and the receiving ship is to have a checklist which contains steps to be made and documented specific for each ship after the bunkering process is completed.

See Appendix C for check-list “After bunkering”.

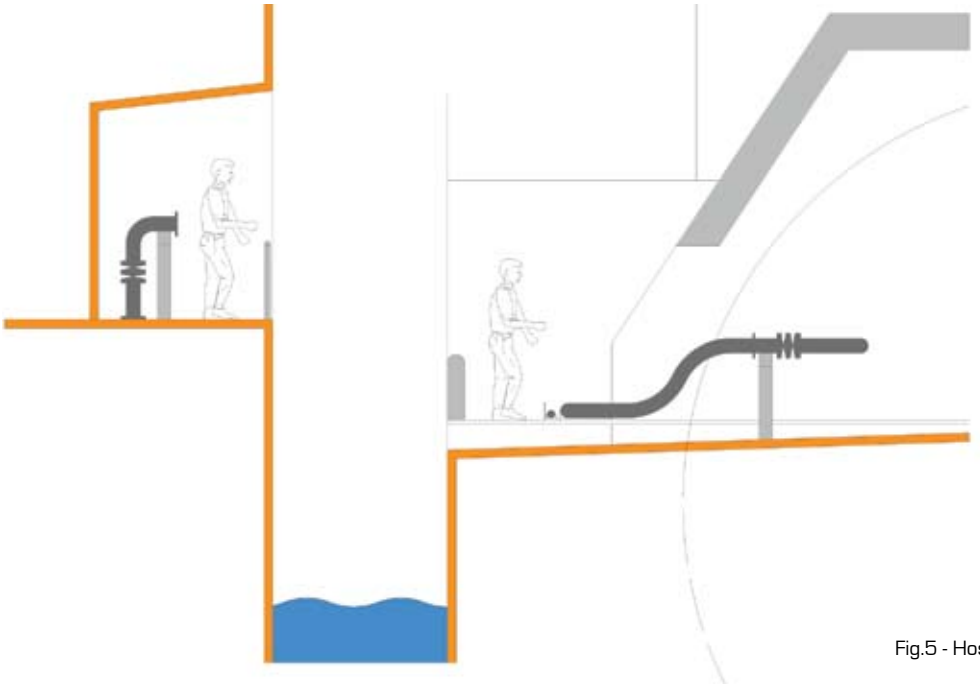


Fig.5 - Hoses in Parking position / Side view

8 EQUIPMENT

8.1 Bunker Hoses

8.1.1 Hose Standards

The hoses used for handling LNG and vapour shall be specially designed and constructed for the products with a storage temperature of – 196° C.

The hoses used for MDO and MGO are more standard type hoses which are available in a larger scale.

8.1.2 Hose Size and Length

All hose strings must have sufficient length to avoid over-stressing and chafing during the bunkering process. To determine the correct hose length, the ships relative freeboard changes and ship movements must be taken into consideration. The hose size is depending on the maximum amount of fuel to be transferred in a defined time frame.

8.1.3 Hose Handling

The hoses shall be handled with great care both during transportation and bunker operations. It is important to keep the hoses sheltered during transportation and to support properly when lifting to avoid damage by kinking. The minimum bending radius (MBR) for each hose must be observed.

8.1.4 Hose Connection

The hose connections should be drip free and preferably quick-connect coupling in order to have a safe and fast connection/disconnection procedure. This type of coupling has two handles to lift, press and rotate to lock position and is designed for the fuel temperature both for functional and operational reasons.

Recommendation : Use drip-free quick-connect couplings for increased safety and time saving reasons.

8.1.5 Hose Inspection and Testing

All hoses shall be part of a specified programme where each hose is to follow a predetermined schedule of inspection, pressure testing and finally replacement (see 5.8). The hoses shall be pressure tested at least every six months and the retirement age should be determined in consultation with the hose manufacturer. This schedule is to be strictly maintained and all information is to be documented and saved on board. The hoses must also be visually inspected before each transfer to detect possible damages during handling. It is very important to monitor the hoses during start-up of the transfer, to verify that there is no leakage which can increase and cause spill.

8.1.6 Marking

Each hose is to be marked according to a specific system. The marking should contain the following information: For which fuel the hose is designed for, manufacturer, max. allowable working pressure, month and year of manufacture, min. bending radius and certification number to identify the specific hose in inspection and testing programme.

Preferably is to use colour markings for each type of fuel according to EN ISO 14276:2008 to minimise the risk of using incorrect hoses.

8.1.7 Differential Pressure Measuring

Each LNG bunker hose shall have a differential pressure measuring system connected to the control system. The pressure will drop quickly in case of a hose leakage which will be detected and the control system will activate the safe shut-down procedure (ESD) which will close down necessary valves and the pump + give audio and visible signals on the bunker ship bridge.

8.2 Bunker Station (Receiving ship)

The bunker station on the receiving ship is preferably located on lower deck along a flat section according to fig.1 (see 5.5.3)

The layout of the bunker station should be new standardised with placement of manifolds and size/type of connections to make the bunkering operation quick and safe (see fig.6- Recommend layout).

The minimum requirement is that class rules are fulfilled and that the hose connection order is same on both ships, to avoiding hoses to cross. There shall not be any sharp edges in the hose handling area. If the receiving vessel has on-board traffic in the vicinity of the bunker station, there should be reinforcements built-in to protect the equipment from traffic impact.

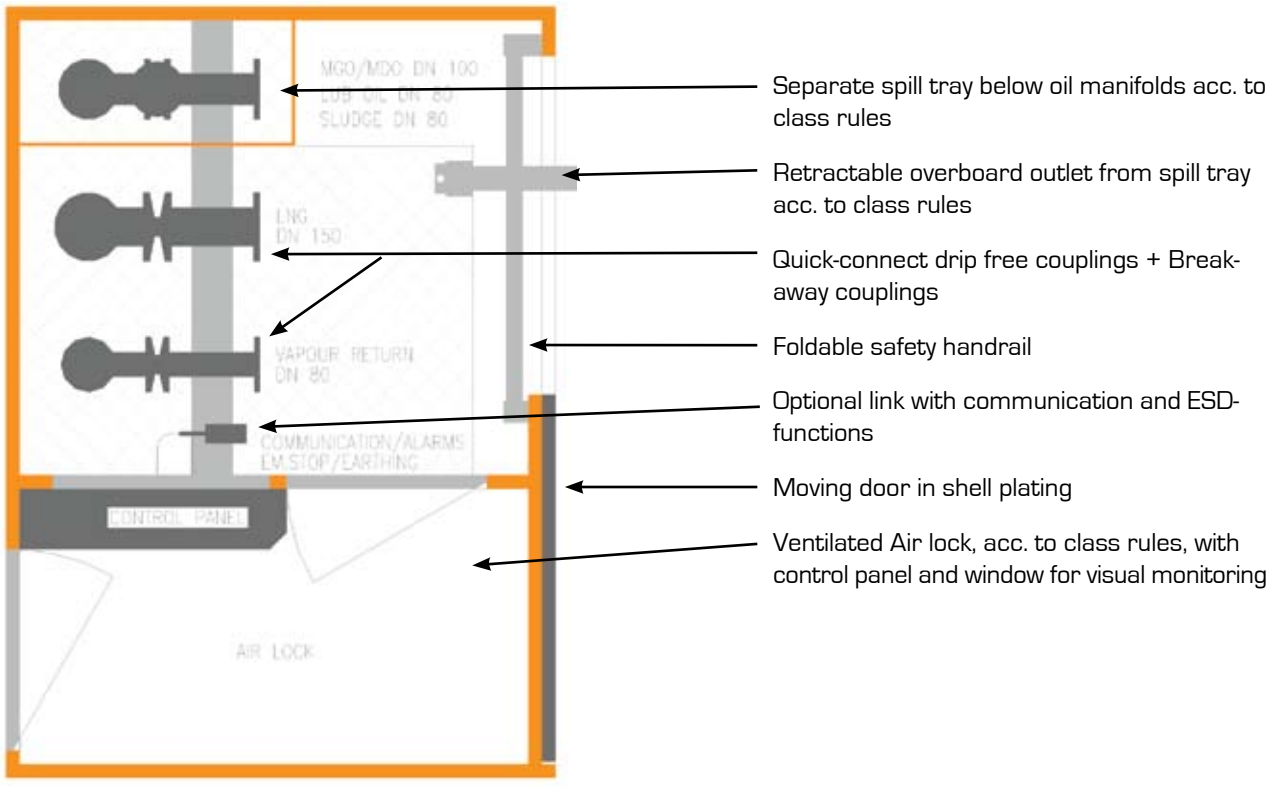

MGO/MDO DN 100
SLUDGE DN 80
LNG
DN 150
VAPOUR RETURN
DN 80
COMMUNICATION/ALARMS
EM.STOP/EARTHING
CONTROL PANEL
AIR LOCK
Separate spill tray below oil manifolds acc. to class rules
Retractable overboard outlet from spill tray acc. to class rules
Quick-connect drip free couplings + Break-away couplings
Foldable safety handrail
Optional link with communication and ESD-functions
Moving door in shell plating
Ventilated Air lock, acc. to class rules, with control panel and window for visual monitoring

Fig.6 - Recommended Layout of Bunker Station (Receiving ship)

8.3 Break-away Coupling

There shall be a break-away (dry-break) coupling on each LNG hose, placed on the receiving ship's manifold to ensure that hoses do not break in case of extreme movement or emergency. The function of this coupling is to be the weakest part of the chain and to break off if forces exceed the limits. Inside the coupling, there are two quick-closing shut-off valves, which immediately close and prohibit leakage.

8.4 Mooring Equipment

It is important that the bunker ship has good quality mooring lines and winches, well placed and sufficiently strong fairleads and bollards. Only closed type and class approved fairleads to be used on the bunker ship. The mooring equipment is to comply with recognised standards, like IMO MSC/Circ.1175. Use soft mooring lines (or tails) for safety reasons (see 11.2)

8.5 Personnel Transfers

Due to safety reasons, it is recommended that transfer of personnel between ships are kept to an absolute minimum. If personnel transfer still is found necessary, there should be an insulated lightweight gangway with rails and a safety net made available and firmly securedw.

8.6 Lighting

When bunkering after daylight hours, it is necessary to have adequate lightning (see 2.5).

Normal deck-lighting should in most cases be sufficient, but portable spotlights or bridge wing spotlights may be useful for night operations. Note that all lights around the bunker area are to be of EX-class.

8.7 Trays below manifolds

Both ships must have insulated stainless steel trays, below the LNG and vapour return manifolds, to prevent damage to the steel hull in case of leakage. The cold LNG-liquid will otherwise cause brittle fractions when contact with mild steel. Each tray should have an outlet overboard which can be a temporary fitted pipe or hose to lead possible spill to the water without contact to the hull.

Drip trays below petroleum manifolds are to be of closed type with sufficient size to handle a minor leakage.

8.8 Gas Detectors

There shall be gas detectors installed in enclosed or semi-enclosed spaces around the bunker area. The detectors are to be connected to the control system and give both visible and audio signals at the actual location in case of a detected leakage.

The bunker operation shall be terminated in case of gas detection and not be resumed until it is safe to proceed.

8.9 Fuel Quality Measuring (Option)

There may be a need for measuring and documenting the quality and quantity of the LNG bunkered, especially in the case of serving several different customers.

The quality could be measured by a Gas Chromatograph, where a small sample is taken and analysed for its energy value and content.

The quantity could be measured by a mass flow meter which continuously monitors the amount being bunkered.

9 LNG CARGO SYSTEM DESCRIPTION

9.1 General

This system description describes the design of a ship to ship bunkering system, as well as the safety aspects to consider when dealing with LNG. The different parts of the bunkering system and their function are presented.

All equipment for handling cryogenic products are to be calculated and designed to endure the characteristics of the liquid gas and environmental influences like wave motion and other weather related issues.

9.2 Equipment

9.2.1 General data

Specification	Storage tank Bunkering ship	Storage tank Receiving ship
Design code	DNV	DNV
Media	LNG/CH4 Natural gas Methane	LNG/CH4 Natural gas Methane
Temperature (°°C)	-196 - +50 (-196 for LIN purging)	-196 - +50 (-196 for LIN purging)
Working pressure (bar)	3	9
Gross volume (m^3)	~1000	~30-500

Specification	Inner piping	Outer piping
Design code	DNV/EN	DNV/EN
Media	LNG/CH4	LNG/CH4
Temperature (°°C)	-196 - +50	-196 - +50
Design pressure (bar)	16	16

9.2.2 Tanks

The LNG bunker ship may be equipped with an insulated storage tank type C for liquefied natural gas (LNG). The tank will be able to contain ~1000 m^3 at 3 bar(g) and -163°C. The tank and its piping system will be placed partly exposed on the deck, which ensures good ventilation. Depending on design there could be more than one tank in the system.

The receiving ship may be equipped with at least one cryogenic LNG tank type C consisting of two tanks; an inner vessel which contains the liquid LNG and a outer vessel/vacuum jacket which is regarded as a secondary barrier. The annular space between the inner and outer vessel, which is filled with perlite is evacuated with vacuum. Compared with other insulants perlite has a good insulating ability even if the space would have “lost the vacuum level”.

The tanks are monitored and secured as per class requirements.

LNG filling of the receiving tank will be performed by spray nozzles in the top of the tank as well as a tube for filling at the bottom. This allows the operator to balance the tank pressure. Filling at the top allows the LNG to cool down and condense the vapour in the tank, which lowers the pressure in the tank.

The principle of level gauging of the tanks is to measure the differential pressure between the top and bottom of the tank. Based on the difference in pressure the amount of liquid in the tanks can be calculated. Differential level transmitters giving 4 to 20 mA are used.

9.2.3 Pumps

The LNG tank on the bunker ship shall be equipped with at least one pump. For redundancy reasons there may be two. The pumps are of the type "In-tank Retractable Submerged Motor Pump". The pump is located in a column in the tank, which allows it to be cooled down at all times. At service the column is purged with Nitrogen and the pump is lifted up. The flow will be regulated by frequency converter together with flow regulating valves.

9.2.4 Bunker Stations (System)

The bunker stations may have one or two hose LNG bunkering system. Three pipelines connect the bunker stations with the LNG tanks. One pipeline is for the liquid LNG, which is partly routed in a vacuum insulated pipe. Another pipeline is for the gas return, which is used when bunkering with 2 hoses. The third pipeline is for nitrogen.

In the bunker station on the bunker ship there is also a tank for high pressure GNG. By letting LNG evaporate in the tank, a higher pressure is achieved in the tank than in the piping system. The pressure can then be used to push the LNG into the tanks after bunkering (stripping). This method minimizes Nitrogen contaminating the fuel.

See also 8.2 Bunker Station (Receiving ship)

9.2.5 Piping System

The piping for the natural gas system on both systems will be an all welded constitution and manufactured entirely in austenitic stainless steel. The piping systems are X-rayed to the extent required by the classification society in order to verify proper execution of the welds and that no cracks are detected. The systems will be designed to be able to withstand pressure pulsation in the case of an e.g. ESD. The piping system is normally maintenance free under normal operation conditions.

The piping systems (both sides) for bunkering consists of a few main systems, the liquid bunker line, the gas return line and the nitrogen system. The systems are equipped both with manually and pneumatically operated valves.

The liquid bunker line is equipped with valves and instruments to control the flow, pressure and quality of the transferred liquid.

From the liquid bunker line there is a recirculation line, "kick back line", leading back to the tank equipped with a control valve. This to be able to recirculate a part of flow from the pump back into the LNG tank to maintain correct pump pressure regardless of the design of the receiving ship.

The gas return line is equipped with valves and instruments to control the gas flow back to the bunker tank. Mainly the flow is regulated by bunker tank pressure. The purpose of the return line is to balance tank pressure in the discharging and receiving tanks.

There shall be a system for gaseous nitrogen onboard the ships. This is needed for purging the piping system from LNG and natural gas after bunkering (inerting). The manually operated valves, which will introduce nitrogen to the LNG system, are located in the bunker stations.

There are also equipment for level and pressure measurement and other safety functions.

9.2.6 Vacuum Insulated Pipes

When bunkering LNG there is an advantage to minimize heat transfer to the liquid. To eliminate heat transfer to LNG, vacuum insulated pipes could be used from the bunker tank to the bunker station and from bunker station to the receiving tank.

9.2.7 Double Trunk Pipes

Double pipe envelopes certain natural gas pipes on the ships. In this case they shall be fan ventilated to discharge possible natural gas leakage to the vent pipe/mast so gas will not be accumulated somewhere on the ship. The manifolds are equipped with gas detectors giving alarm to the ship's IAS in the case of gas leakage. On the LNG bunkering ship some piping will be on the open deck and have natural ventilation.

9.2.8 Safety Valves

The system includes valves regarded as ordinary safety relief valves as well as so called thermal relief valves. The tanks' main safety valves are designed to meet requirements for a LNG tank. Thermal relief valves are designed to meet capacities in a trapped volume in pipes. A safety valve exhausts/vents to a vent mast.

To secure that not both safety valves to the LNG tanks are out of operation at the same time, the safety valve system incorporates an "interlock system". The interlock system consists of lockable valves and a set of keys that permits only one of the safety valves on each tank to be closed.

The bunker ship tank is equipped with an overflow valve, which will be able to absorb sudden rise in pressure in the case of e.g. an ESD shut down.

9.2.9 Vent Mast

There will be the possibility to divert gas from different parts of the system to the atmosphere through a vent mast. The LNG tanks' safety valves will also exhaust to this vent mast, as well as the nitrogen used for purging.

9.2.10 ESD System

Automatic Emergency Shut Down "ESD" systems are required on both ships. In the case of an ESD trip different valves and/or pumps will close and shut down parts of the system depending on which alarm that have been tripped.

For description and example reasons - see chapter 10

Control System

The LNG system will be governed by the ship's IAS computer system. The IAS receives signals from instruments belonging to the system and after evaluating these signals the IAS performs activities depending on which "mode" of operation is chosen.

The pressure of the tanks is governed automatically. Manual mode can be chosen when there is need to by-pass automatic valve control in order to perform special tests with the system regardless if it is in duty/operation or not.

The control system should monitor key components for safety issues regarding overload and overheating and key controls and equipment should have standardised marking.

Electrical & Pneumatic Cabinets

On both the ships there shall be an electric and pneumatic cabinet at the bunker station as well as at the cold box. In the cabinets there are safety barriers to assure that the energy in a cable and instrument always is lower than what is required to ignite a spark. The cabinet has solenoid valves, with a toggle to facilitate manual test possibilities, which provide the actuators on the valves with air. On the electric/pneumatic cabinet at the bunker station there are indicators, which show the tank content and tank pressure in the tanks. ESD valves are delivered with limit switch and solenoid valve mounted on the valve. Pneumatic valves are of the type "fail close". Loss of electrical power or service air will also close pneumatic valves.

9.3 Process

The bunkering process starts with the connection of the communication link (optional) between the two ships. Then the hoses for the transfer of LNG between the ships shall be connected; the liquid filling hose and the gas return hose. The reason there is need for two hoses is to be able to handle the raise in pressure that will occur in the receiving tank. Gaseous natural gas is led back to the bunker ship through the gas return hose, balancing the pressure in the two tanks.

Note that the gas return is not utilized if the top filling reduces the receiving ship tank pressure sufficiently.

The submerged pump in the tank on the bunkering ship is controlled by a frequency converter. The frequency converter, together with the "kick back line" on the piping system, allows the bunkering ship to adapt to different design on the receiving ship by adjusting the flow of LNG. The flow is further controlled with flow meters flow regulating control valves.

Pressure, flow and temperature transmitters are placed on both the bunkering and the receiving ship to monitor the bunkering process. Close by the bunkering stations there will be an electric cabinet with indicators.

When the level indicator for the receiving ship indicates that the required level is reached the bunkering shall end. After the bunkering, the piping system and hoses must be purged with nitrogen. Both ships shall have a nitrogen supply to be able to perform purging. However, before using the nitrogen any residual liquid in the system shall be pushed back into the tanks. This is performed using the purge tank on the LNG bunkering ship, which contains natural gas with a higher pressure then the rest of the system. As that natural gas is released into the system the liquid is flushed from the system into the tanks. Now the hoses can be disconnected between the ships.

When the hoses are disconnected the nitrogen is let into the piping system close to the tanks; any natural gas is then purged from the system to the vent masts.

10 ESD PHILOSOPHY

10.1 Reference

LNG Cargo System Description - See chapter 9

P&ID - See Appendix E

10.2 ESD Analysis

The main purpose of the "ESD" Emergency Shut Down system" is to shut down ignition sources to reduce the risk for an explosion in case of gas leakage during the bunkering process. The bunkering process for the receiving ship is regarded as terminated when so according to the receiving ship's User Manual. The bunkering process for the bunker ship is regarded as terminated when so according to the bunker ship's User Manual.

10.3 The Receiving ship

The gas system onboard this ship is assumed to be of the same type as gas systems delivered today for gas fuelled ships. Procedures are foreseen to be enchanted to meet refined requirements as available time for bunkering. The following main parts can be identified:

- LNG tank type "C" with a cold-box (tank room) including product (VAP) and pressure build up (PBU) vaporizer
- bunker station
- pipes from bunker station to the cold-box
- pipes from the cold-box to the gas engines
- Nitrogen (N2) for inerting stowed or generated onboard or supplied from ashore

This implies that the ship and gas system comply with DNV's rules for gas fuelled ships in all respects as gas detection, fire detection, ventilation, double piping, trunks, etc. Existing gas fuelled ships bunker today from ashore based fixed or mobile system according to existing procedures described in the User Manuals for these LNG receiving ships. The LNG is usually transferred from the supplying tank by a cryogenic pump or by the pressure in the supplying tank. Power management , redundancy and control system for the ship is fully covered by existing class requirements. See chapter 10 for system description for receiving ship.

10.4 The Bunker ship

The bunker ship is a cargo ship. There has not been built a dedicated LNG bunker ship as today but the gas system onboard can be assumed to include gas systems delivered today for gas fuelled ships and LNG carriers. The following main parts can be identified:

- LNG tank type "C" with a submerged pump
- Cold-box (tank room) with valves and equipment
- Bunker station with valves and equipment
- Pipes from bunker station to the cold-box
- Pipes from the cold-box to the gas engines
- Pump unit for transferring LNG
- Nitrogen (N2) for inerting stowed or generated onboard
- Cargo control system

The gas system has to comply with class rules for liquefied gas carriers and gas fuelled ships in all respects as gas detection, fire detection, ventilation, double piping, trunks, etc. Existing LNG carriers bunker today from ashore based fixed or mobile system according to existing procedures described in the User Manuals for these carriers. The LNG can be transferred from the supplying tank by a cryogenic pump or by the pressure in the supplying tank if it is high enough. The pump alternative requires a more refined control and shut down system to protect the pump. Power management , redundancy and control system for the ship is fully covered by existing class requirements.

See chapter 9 for system description for the bunker ship.

10.5 Transfer Interface when Bunkering

LNG is transferred from the bunker ship to receiving ship through the liquid fill line. The gas return line from the receiving ship to the bunker ship serves the purpose to equalize the pressure in the receiving ship and bunker ship. The gas return line can be used if the pressure in the receiving ship and bunker ship are compatible. This implies that the maximum pressure rating for both tanks are the same. Common practice today when bunkering gas fuelled ships (excluding carriers) is not to use a gas return line. The following bunkering interface areas can be identified:

- The bunker station on the receiving ship is a compartment that is closed with an air lock towards cargo deck or interior but open to sea during bunkering. If the bunker station is equipped with a water tight door in the shell plating gas detection is active when not bunkering.
- The bunker station on the bunker ship is a sheltered area with bunker manifolds that need not to be closed with an air lock. However a sheltered “haven” in case of hazardous situation is foreseen near the bunker manifold.
- The liquid hose connection on the bunker ship. The liquid hose is generally permanently connected with flanges and the hose has a dedicated stowed position when not in use.
- The gas return hose connection on the bunker ship. The gas return hose is generally permanently connected with flanges and the hose has a dedicated stowed position when not in use.
- A break away coupling is mounted on all hoses on ends connected to the receiving ship. In case of out of limit and/or uncontrolled movements/displacements by the receiving ship and bunker ship hoses will be released from the hose connection on the receiving ship. The breakaway couplings are drip free.
- The receiving ship and bunker ship have instrumentation on both sides of the LNG hose.
- Ship movements and displacements between receiving ship and bunker ship.
- Hose handling.
- Receiving ship and bunker ship hull shell plating.
- System and control communication.
- Human communication.

Bunkering area and adjacent phenomenon’s are not regarded in this ESD philosophy. They are viewed elsewhere.

10.6 ESD Philosophy

In case of a hazardous situation concerned systems will be shut down by an "ESD" Emergency Shut Down system". The objective is to eliminate ignition sources to reduce the risk for an explosion in case of gas leakage during the bunkering process. Uncontrolled cold LNG flow can cause personnel and structural damages. Individual documents and plans for both receiving ship and bunker ship are made indicating gas hazardous zones with gas detectors and ventilation. These documents are essential since the receiving ship is unloading and loading at the same time as when bunkering. The receiving ship is also bunkering fuel oil at the same time as when bunkering LNG. The following can initiate an ESD shutdown:

- pressure
- flow
- temperature
- loss of instrument pressure
- loss of electricity
- pump failure
- gas detection
- fire detection
- ventilation
- out of range receiving ship and bunker ship drift/displacement
- manually initiated shutdown

Levels for alarms can be found in DNV's "Gas fuelled engine installations" chapter control, monitoring and safety systems. Gas systems are controlled and monitored by the ships IAS systems. These systems can generally be monitored and controlled independently at the bridge and engine control room. There is also an independent ESD panel. At the bunker station on the receiving ship there is an emergency stop button. The receiving ship and bunker ship have their own independent ESD philosophy that initiates ESD shutdowns in addition to what is initiated by the transfer interface. To be noted is that generally there are no gas detectors in the bunker station area effective during bunkering. A water curtain covering the bunkering area to mitigate damages in case of LNG leakage can be used.

11 EMERGENCY OPERATIONS

11.1 Emergency Signal

There shall be an agreed upon emergency signal between the ships, like in IMO resolution A 830, which shall be activated in case of an emergency on either ship. All personnel should then take actions and proceed according to the contingency plan (see 11.3).

11.2 State of Readiness for an Emergency

Both ships are to be at a high state of readiness at all times during bunkering operations. Following arrangements should be made on both ships:

- ESD-system tested and in operation mode (see 11.6.3)
- Emergency stop box (or Link) should be led from bunker to receiving ship (see 11.6.3)
- Fire-fighting equipment ready for immediate use (see 3.7.7)
- Ships prepared to disconnect hoses at short notice
- Axes placed at bunker ship mooring stations for quick release of mooring lines
- Soft rope mooring lines (or tails) for easier emergency cutting (see 8.4)
- Ships to have main engines ready for immediate use
- Outlet from LNG spill trays to be led overboard and away from hull (see 8.7)
- There is a possibility to have a water curtain system which , in an emergency situation, sprays water over the ship sides around the bunker stations to protect the hulls from direct LNG contact

11.3 Contingency Planning

Due to the risk for accidents and the potential consequences, it is required that each ship has contingency plans for dealing with emergencies. A contingency plan is a summary of individual emergency procedures and shows emergency duties for all ship personnel and plans for taking care of passengers. The contingency plans should be integrated with port and local authorities and agreed upon between both ships prior to commencing operations.

The following emergencies are example of sections in the contingency plan:

- Fire on either ship
- LNG leakage
- Hose failure
- Hose quick release arrangements
- Mooring line failure
- Communication failure
- Personnel injuries (frost burns, suffocation etc.)
- Emergency departure procedure
- Oil pollution from additional petroleum bunkering
- Fender burst

The emergencies are to be evaluated to see if some of the risk scenarios are more likely to occur, which should be included in the contingency plan.

11.4 Emergency Situations

In an emergency, both ships Masters should evaluate the situation and act accordingly, bearing in mind that too hasty decisions can make the emergency worse.

The following actions should be made, step by step, in case of an emergency :

1. Sound the agreed emergency signal (see 11.1)
2. Activate ESD-system to stop the transfer (see 11.6.3)
3. Initiate emergency procedures (see 11.3)
4. Alert crews on both ships
5. Send mooring personnel to stations
6. Notification to port
7. Notification to authorities, if necessary
8. Purge bunker hoses with nitrogen (see 7.1)
9. Disconnect bunker hoses
10. Confirm that engines are ready for immediate use
11. The bunker ship Master is to make the decision to stay or to go

11.5 Safety Drills

Various emergency events can be contained and minimised by using safety drills according to a specified system. The ship crews should frequently exercise fire and safety drills with demonstration of equipment. All personnel should be well informed about their duties and the location of emergency stations and other points of interest for safety reasons for both crew and passengers.

11.6 Advice on some Emergencies

11.6.1 Emergencies during Manoeuvring

The Master of the bunker ship shall always be prepared to abort the berthing procedure, if necessary. Both ships are to inform each other immediately about any change of actions. The berthing process must comply with *"International Regulations for Preventing Collisions at sea"*.

11.6.2 Procedures for Communication Failure

The berthing manoeuvring shall be aborted if there is a communication failure during approach. New approach shall not be resumed before communication is restored.

Communication breakdown during the transfer should lead to immediate suspension of all operations and sounding of the emergency signal. Operation shall not be resumed before communication is restored.

11.6.3 Activation of Emergency Shut-Down Systems (ESD)

Activation of the ESD-system includes stopping of the pumps on the bunker ship and closing of the bunker valves on both ships. ESD actuators are to be located at strategic locations around the bunker area to provide a quick shutdown in case of emergency. The bunker ship should preferably provide an emergency stop (or link - see 5.6) to the receiving ship in order for both ships to be able to stop the pumps. The pipe system is to be designed to handle quick closing of valves (bypass to avoid dangerous pressure surges). Each ship's fire system should be linked to the ESD-system.

For more detailed description: See chapter 10

11.6.4 Procedures for Leakage / Gas Accumulation

Bunker operation is to be stopped and ventilation shut off in case of a minor LNG leakages. There are stainless steel spill trays below both manifolds where possible LNG spill will vaporize. The vapour cloud size will depend on the size of the leakage.

Transfer operation shall not be resumed before the leakage is corrected and the vapour cloud has dispersed, which is monitored by gas detectors at both ships bunker stations (see 8.8).

11.6.5 Accidental LNG Bunker Fuel Release

The bunker operation is to be stopped immediately, ventilations on both ships shut off and port officers notified in case of a major LNG release. There are stainless steel spill trays below both manifolds with a lead overboard to direct any possible LNG spill away from the hull and into the water where it will vaporize which can cause RPT (Rapid Phase Transition) if the spill amount is large enough. Depending on the size of leakage, the vapour cloud size may be significant as LNG expands 600 times in volume from liquid phase to vapour. A major leakage may lead to hull damages if the cold LNG comes in direct contact with the steel. This is not critical for the ships immediate safety, but will require instant repairs at a shipyard.

A LNG release must be reported to port and authorities. Further transfer shall not be resumed before the reason of leakage is corrected and no damages are reported. Agreement for continuation is made with port and authorities.

11.6.6 Accidental Oil Bunker Fuel Release and Oil Pollution Control

The bunker operation is to be stopped immediately and reported to port and authorities. The transfer must remain suspended until it is agreed upon with port and authorities.

For an oil leakage or petroleum fuel release, there shall be a contingency plan activated with SOPEP (Shipboard Oil Pollution Emergency Plan) and VRP (Vessel Response Plan) to cover the risks.

Oil Bunkering (Example)

12 GAS HANDLING

12.1 General

This gas handling descriptions explains the properties of LNG and natural gas, as well as the dangers of handling the gas and the precautions needed to be taken.

12.2 Safety Information

12.2.1 Cryogenic Liquids

A cryogenic liquid is defined here as a gas that has been liquefied through cooling. A gas is technically defined as being cryogenic when it has been cooled to a temperature below - 160°C at normal atmospheric pressure and has liquefied. The gases in liquid state dealt with in the LNG road tanker loading station are natural gas (which consist mainly of methane) and nitrogen (for pre-cooling).

Cryogenic liquids are classified as dangerous substances and must be handled according to strict rules. It is of great importance that all personnel receive the appropriate training to ensure the safe handling of cryogenic liquids.

12.2.2 Risks when inhaling Methane (CH4) Natural Gas

Methane, which LNG predominantly consists of, is low toxic when inhaled and has in general no specific physiological symptoms. However, the substance is suffocating and the effect is proportional to the decrease of the partial pressure of oxygen in the inhaled air, which is established when mixing methane and air.

When the oxygen content has decreased to three quarter or less of the normal content asphyxia will occur. The human body will interpret this as oxygen deficiency and reacts (at concentrations 50% by volume methane in air) with obvious suffocation symptoms like difficulties in breathing and rapid breathing at the same time as the ability to respond deteriorates and mussel coordination weakens. Severe cases (by concentrations of 75% by volume methane in air) can lead to unconsciousness and death.

It is therefore of utmost importance that all confined spaces where someone is to enter are sufficiently and thoroughly purged with air in a planned manner and that the oxygen and hydrocarbon content is measured before entering the space. This applies for spaces where anunintentional exhaust might have occurred.

Asphyxia is devious in the sense that it comes sneaking and the victim seldom notices it before too late. By asphyxia the victim is quickly taken out into fresh air and given oxygen or artificial respiration. Medical doctor is required immediately.

Note! After a discharge of gas into an confined space it is extremely important to effectively flush the area with air, and measure the oxygen content before personnel entering the area.

12.2.3 Risks when inhaling Nitrogen (N2) Gas

Nitrogen is used for purging of equipment; either before dismounting, to get it free from natural gas, or after it has been opened for maintenance, to get it free of air and humidity. It is also used for purging of hoses.

Liquid nitrogen (-196°C) can be used for pre-cooling and low temperature testing of equipment before taken into use with LNG. Release of liquid nitrogen leads to formation of a large volume of gas as the liquid evaporates. If nitrogen is released in quantity in a confined space the oxygen content of the air may drop radically, causing an acute risk of asphyxiation. Increased N2 content do not affect the respiratory system, which means that unconsciousness and asphyxiation occur without warning.

Note! After a discharge of gas into a confined space, it is extremely important to effectively flush the area with air, and measure the oxygen content before personnel entering the area.

12.2.4 Fire

Natural gas is highly hazardous for fire and explosion. The explosion limit for natural gas is 5 – 15 percent by volume in air at 20 °C. Natural gas is odour- and colourless.
For a fire or an explosion to occur three conditions have to be fulfilled:

- An igniting spark (a certain amount of energy)
- Combustible material
- Oxygen

As natural gas is combustible and there is oxygen in the air, only an igniting spark is required to establish a fire in the event of a natural gas leakage. An igniting spark can be established for instance by a metal tool hitting a pipe.

12.2.5 Risks when in contact with Cold items and Gas

Methane (LNG) or nitrogen (LIN) in liquid state or cold gas can generate severe chill injuries on tissue and eyes. These chill injuries remind a lot of burn injuries. Bear in mind, that even touching equipment like pipes that are or have been in contact with LNG or LIN, can generate much more severe chill injuries than the liquid itself. If methane or nitrogen in liquid state comes in contact with objects that have a higher temperature than the liquid, furious boiling will be encountered and the temperature of the object will decrease rapidly (Boiling temperature for LNG at normal atmospheric conditions is -160 °C and for LIN it is -196 °C).

Human tissues exposed to chill injuries are rinsed in abundance with water of temperature not higher than that of the human body. Warming up with warm water or rubbing makes the wound worse. A medical doctor is to be consulted soonest.

LNG Bunker Ship (Example)

12.2.6 Personal Protection

It's essential to use protective gloves for the hands, goggles for the eyes and cover the skin (face shield) where the possibility of contact with liquid, cold pipes and cold equipment or cold gas exists. Gloves should be leather (not rubber). Shoes or boots should not have open metal items as these can cause sparks. To prevent electrostatic charge build-up in the human body all footwear should be made of conductive or dissipative material to allow continuous grounding. Use ear protection against noise from safety valves.

12.2.7 Vapour Fog, Mist

When exhausting/venting cold gas in air they mix, and as a consequence of the lowered temperature mist will arise. The mist is often the cause of injuries, as people escaping from compartments stumble over different objects due to lowered visibility.

Release of gas in liquid state leads to formation of a large volume of cold gas as the liquid evaporates, resulting in large formation of mist.

Note! In the case of extensive release, the gas completely replaces the air around the release outlet, which results in a mist-free zone.

12.2.8 Trapped Liquid

If liquefied gas is trapped in a pipe between two valves or a tank without an exit, the pressure in the tank or pipe will rise till the pipe or tank bursts. The consequence can be severe injuries on personnel. All pipe sections and tanks must therefore be secured with thermal relief valves.

If the system is due for modification, you always have to bear in mind the possibility of trapped liquid in a pipe system between two valves. Mistakes can lead to fatal consequences (tube cracking).

12.2.9 Training

All personnel shall be well trained for their duties, as faulty operation can cause damage to equipment and above all to people's health. Training in taking care of injured personnel, how to take care of damaged equipment and fire fighting has to be attended to regularly. Just as vital as to perform the training is to check the result from the training, and that the training continues till an acceptable level of the training has been achieved.

References

Reference is made to international rules set up by IMO, classification rules and national legislation and guidelines as applicable:

1.	Ship-to-Ship Transfer Guide (Liquefied Gases)	ICS / OCIMF / SIGTTO
2.	Ship-to-Ship Transfer Guide (Petroleum)	ICS / OCIMF
3.	IGC Code	IMO
4.	IGF Code (Interim)	IMO
5.	SOLAS	IMO
6.	MARPOL 73/98	IMO
7.	STCW 78/95	STCW
8.	Rules for “Gas fuelled Engine Installations”	DNV
9.	Port Regulations	Gothenburg Harbour
10.	Standard Marine Communication Phrases	IMO
11.	ESD arrangements & linked ship/shore systems for liquefied gas carriers	SIGTTO
12.	Swedish Civil contingencies agency – MSB, Swedish regulations on land	
13.	Swedish transport agency – maritime department, Swedish regulations at sea	

Appendix A CHECK-LIST BEFORE BUNKERING

Name of Ship : .....

Place of bunkering : ..... Date : .....

General checkpoints	Bunker Ship Y	Bunker Ship N	Receiving Ship Y	Receiving Ship N
1. Authorities/Port permission for bunkering ?	☐	☐	☐	☐
2. Are ships compatible for bunkering regarding mooring and hose connections ?	☐	☐	☐	☐
3. Is the transfer area ok for approach, mooring and bunkering ?	☐	☐		
4. Are light conditions satisfactory ?	☐	☐		
5. Is the EX-Zone activated ?	☐	☐	☐	☐
6. Are earth indicator lights on switchboard/control panel ok ?	☐	☐	☐	☐
7. Are main radio transmissions restricted ?	☐	☐	☐	☐
8. Are accomodation doors around bunkering area closed ?	☐	☐	☐	☐
9. Is the safety zone activated ?			☐	☐
10. Are personell protection equipment checked and ready for use ?	☐	☐	☐	☐
11. Is the ESD-system tested and ready for use ?	☐	☐	☐	☐
12. Is the mooring equipment checked and ready for use ?	☐	☐		
13. Are the fuel transfer hoses visually checked ?	☐	☐		

LNG-Tank temperature (°C)	
LNG-Tank pressure (Bar)	

.....

Signature

When duly signed this document is to be kept on board at least 3 months

Appendix B CHECK-LIST PRE-TRANSFER Part 1

Name of Bunkership : .....

Name of Receiving ship : .....

Place of bunkering : ..... Date : .....

VHF-channel to be monitored during bunkering : .....

General checkpoints	Bunker Ship Y	Bunker Ship N	Receiving Ship Y	Receiving Ship N
1. Do the weather conditions permit bunker operations ?	☐	☐	☐	☐
2. Is the receiving ship safe at berth ?			☐	☐
3. Is the mooring plan agreed upon and mooring of the ships carried out in accordance with this plan ?	☐	☐	☐	☐
4. Are primary (and secondary if needed) fenders in proper positions ?	☐	☐		
5. Is safe communication in agreed language established between ships ?	☐	☐	☐	☐
6. Are radio transmitter aerials earthed, radars switched off and VHF on low power ?	☐	☐	☐	☐
7. Are smoking regulations, naked light and galley requirements being observed ?	☐	☐	☐	☐
8. Are emergency signals and shutdown procedures agreed upon ?	☐	☐	☐	☐
9. Are fire fighting equipment checked and ready for immediate use ?	☐	☐	☐	☐
10. Are navigational signals indicating bunkering operation displayed ?	☐	☐	☐	☐
11. Are the fuel transfer hoses checked to be of the correct type, in good condition and ok according to the maintenace/replacement system ?	☐	☐		
12. Are the fuel transfer hoses properly connected and supported ?	☐	☐	☐	☐
13. Are all fuel transfer manifolds, not in use, blinded ?	☐	☐	☐	☐
14. Are valves set to to their correct position ?	☐	☐	☐	☐
15. Are receiving tanks gauged and fuel transfer quantity to be transferred agreed upon ?	☐	☐	☐	☐
16. Is the maximum pump rate and the topping up rate agreed upon by the responsible officers on both ships ?	☐	☐	☐	☐
17. Are there trained and educated persons on watch at bunker stations, close to the emergency stop, on both ships ?	☐	☐	☐	☐
18. Are drip trays in position and ready for use below manifolds in use ?	☐	☐	☐	☐

Appendix B CHECK-LIST PRE-TRANSFER Part 2

Specific checkpoints for LNG and MGO transfer	Bunker Ship Y	Bunker Ship N	Receiving Ship Y	Receiving Ship N
19. Are vapour return connections properly connected and supported ?	☐	☐	☐	☐
Specific checkpoints for MDO and MGO transfer	**Bunker Ship Y**	**Bunker Ship N**	**Receiving Ship Y**	**Receiving Ship N**
20. Are all deck scuppers in bunker area properly closed ?	☐	☐	☐	☐
21. Are sea and overboard discharge valves tightly closed and lashed or sealed ?	☐	☐	☐	☐
22. Are all cargo/bunker tank lids closed and and ullage ports protected by proper flame screens ?	☐	☐	☐	☐

	Bunker Ship	Receiving Ship
LNG-Tank temperature (°C)		
LNG-Tank pressure (Bar)		

	LNG	MDO	MGO
Quantity to be transferred			
Start rate (m3/h)			
Max. transfer rate (m3/h)			
Topping up rate (m3/h)			
Max. pressure at manifold (Bar)			

.....
Signature by receiving ship

.....
Signature by bunkering ship

When duly signed this document is to be kept on board discharging vessel at least 3 months

Appendix C CHECK-LIST AFTER BUNKERING

Name of Ship : .....

Place of bunkering : ..... Date : .....

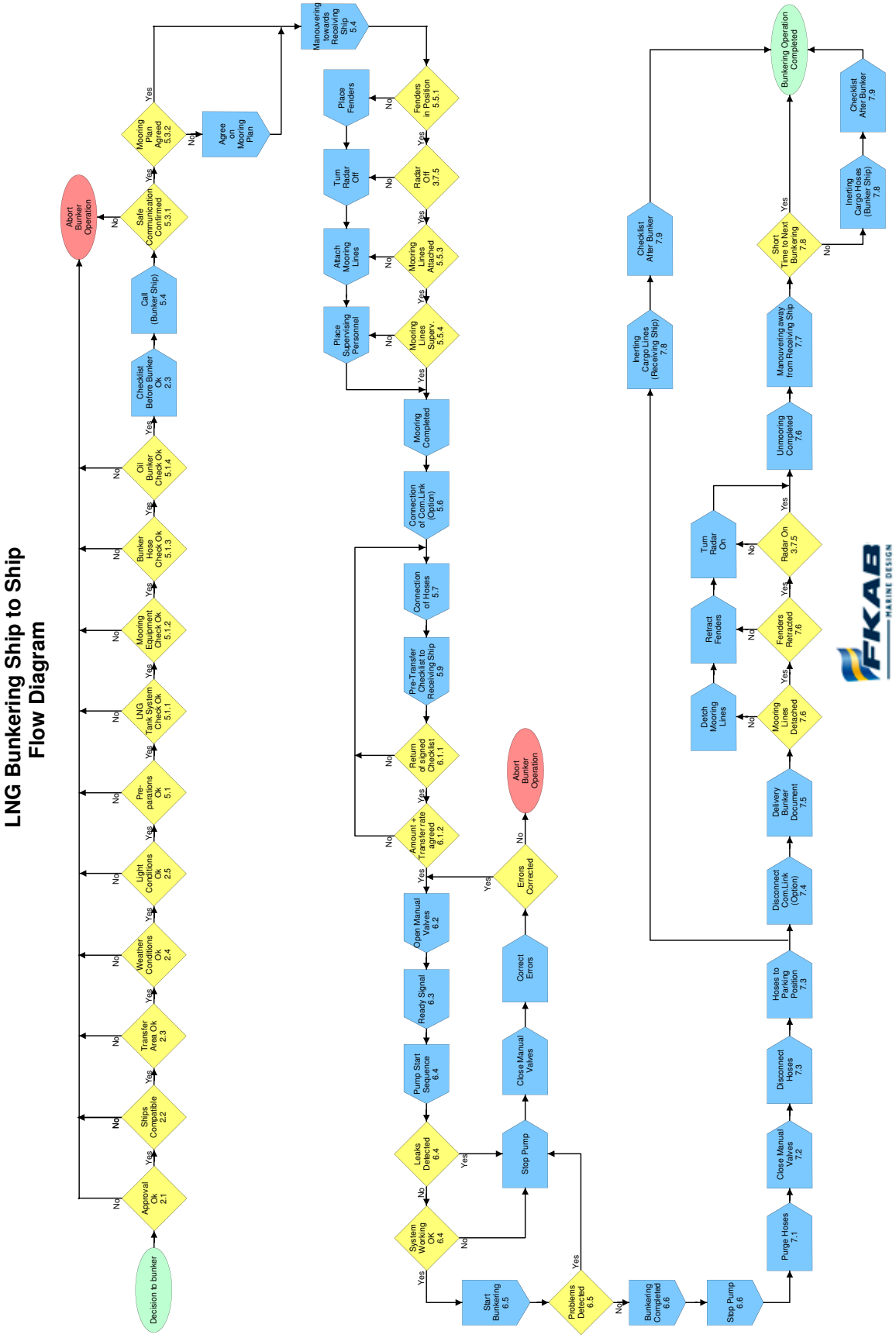
General checkpoints	Bunker Ship Y	Bunker Ship N	Receiving Ship Y	Receiving Ship N
1. Are the fuel transfer hoses purged ?	☐	☐	☐	☐
2. Are the remote controlled fuel transfer valves closed ?	☐	☐	☐	☐
3. Are the manual fuel transfer valves closed ?	☐	☐		
4. Are the fuel transfer hoses disconnected and placed in their parking position ?	☐	☐		
5. Are the Transfer Documents signed and delivered ?	☐	☐	☐	☐
6. Are the mooring lines retracted ?	☐	☐		
7. Are the fenders retracted ?	☐	☐		
8. Is the radar turned on ?	☐	☐		
9. Are the fuel transfer lines inerted ?	☐	☐	☐	☐

.....

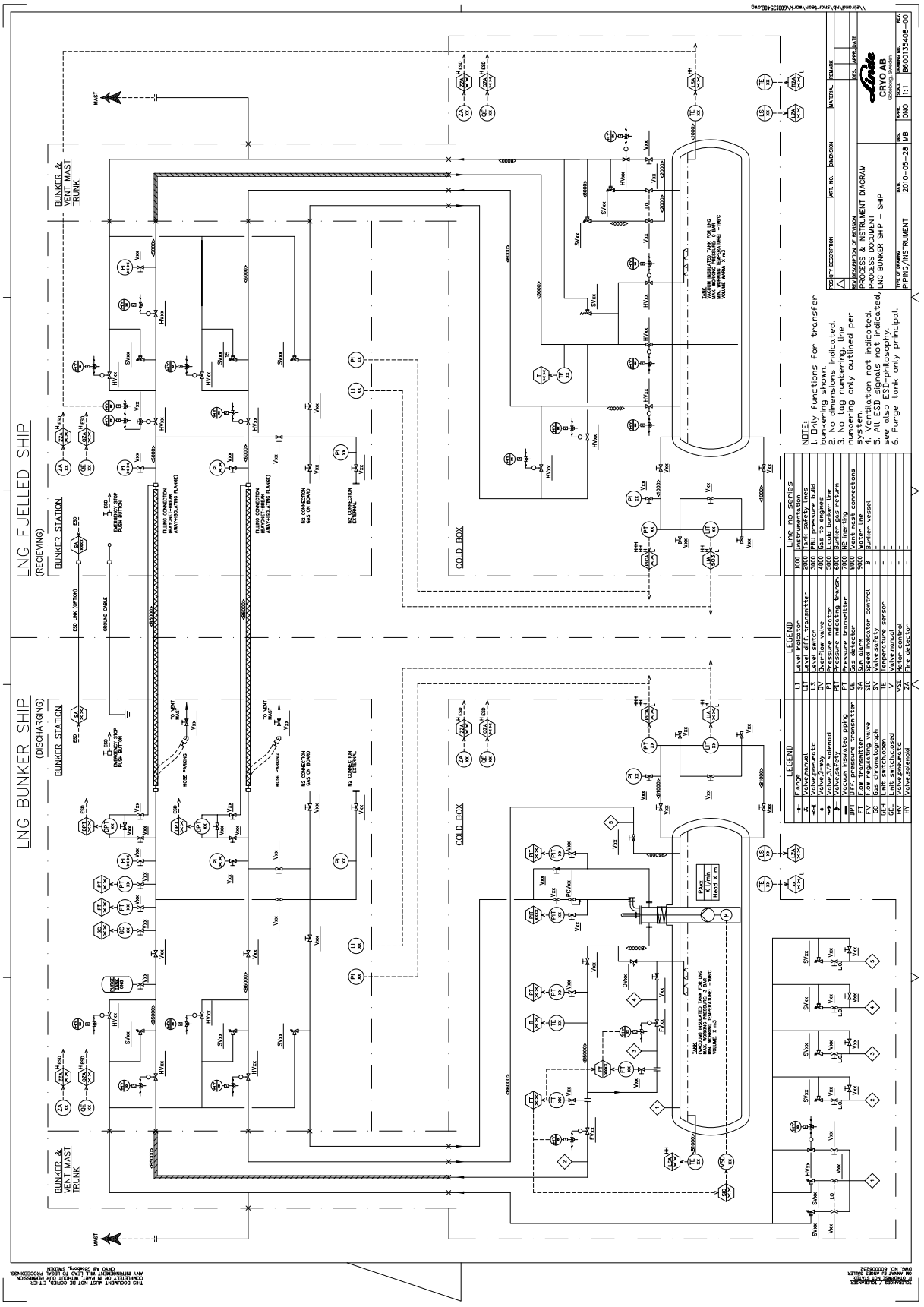
Signature

When duly signed this document is to be kept on board at least 3 months

Appendix D – Flow Diagram LNG Ship to Ship bunkering



Appendix E – LNG Cargo System P&ID



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